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ABSTRACT

This curriculum guide is one of a series of automotive service specialty publications that continues students' training in the automotive service trade by providing instruction in the electrical systems speciality. It is based on the National Institute of Automotive Service Excellence tasks lists. It contains nine units. Each unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for the teacher, pretests, pretest answers, information sheets, assignment sheets and their answers or job sheets and their practical tests, written tests, and written test answers. Transparency masters, handouts, pretests, and written tests are included in the instructor edition only. Unit topics are as follows: electrical system repair requirements, electronic system repair requirements, starting system, charging system, lighting, driver information system, horn and washer/wiper systems, motorized accessories, and miscellaneous electrical components. A basic skills matrix correlates competencies and skills. (YLB)

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ED 385 675

Automotive Service Series

Electrical Systems Specialist

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Teacher Edition

Oklahoma Department of
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Electrical Systems Specialist

Teacher Edition

Developed by the
Curriculum and Instructional Materials Center
for the Division of Trade and Industrial Education
Oklahoma Department of Vocational and Technical Education

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ELECTRICAL SYSTEMS SPECIALIST

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FOREWORD

This is one in a series of eight automotive service specialty publications that is based on the National Institute of Automotive Service Excellence (ASE) task lists. This series provides instruction for all high-priority competencies established by ASE and will contribute greatly to an auto service technology program's ability to meet the requirements of a nationally certified training school.

The ASE competencies are developed by industry to meet the industry's need for quality technicians. This curriculum addresses that need. The industry and education committee that has validated the technical accuracy of this material is commended for outstanding service and commitment to the quality of these instructional units. The instructors and students who use this material are challenged to have the same commitment to excellence.

We trust that this instructional material will meet students' needs as they prepare for careers in manual drivetrain and axles service.

Dr. Roy Peters, Jr., State Director
Oklahoma Department of Vocational and
Technical Education

Ivan Armstrong, State Supervisor
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Oklahoma Department of Vocational and
Technical Education

PREFACE

The purpose of *Electrical Systems Specialist* is to continue the students' training in the automotive service trade by providing instruction in this specialty area. This publication is one in a series of eight publications for automotive specialty areas. Other areas included in this series are brakes, steering and suspension, engine repair, engine performance, heating and air conditioning, manual drivetrain and axles, and automatic transmission/transaxle.

Instructors are faced with the challenge of teaching the skills and related information necessary for their students to become the highly-qualified automotive service specialists that are in demand today. This curriculum is designed to help instructors meet this challenge. The objectives in this curriculum are based on those National Institute of Automotive Service Excellence (ASE) tasks that are required of an electrical systems technician.

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The Curriculum and Instructional Materials Center (CIMC) extends its appreciation to those individuals who played important roles in the development of *Electrical Systems Specialist*. To the writers, Mrs. Vickie Elias and Sandra Dutreau Perky Williams, your work is to be commended.

Special appreciation is extended to the professional automotive technicians and vocational educators who so generously contributed their substantial expertise, talents, and time to serve on the Electrical Systems Specialist curriculum validation committee.

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To the Superintendents of the Area Vocational Technical Schools/Centers, a special thank you for allowing your instructors to be out of the classroom to complete this project.

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Only with the close cooperation of the Curriculum and Instructional Materials Center staff was this curriculum developed. Sincere thanks are shared with Dr. Brenda Stacy, CIMC Coordinator, Dr. Lynna Ausburn, Development Coordinator, Mr. Greg Pierce, Former CIMC Coordinator, and Ms. Sheila Stone, Former Development Coordinator.

Special appreciation is offered to the other individuals on the CIMC staff who functioned in important supportive roles throughout the development of Electrical Systems Specialist curriculum: Mrs. Barbara Kuehl, former CIMC secretary, who provided all correspondence support with committee members; Mrs. Terri Tomson, secretary, who provided all assistance on the organization and tracking of permission letters for the illustrations; and Camille Baker, Beth Ann Chlouber, Lynette Johnson, and Connie Romans, Technical Writers, who proofread the final copy. Thanks also are extended to the many other members of the CIMC staff who so generously provided the support, help, and advice that was needed for this project.

Special recognition and thanks are also extended to other individuals within the Oklahoma Department of Vocational and Technical Education involved in the development process: Rose Primeaux and Margie Kirkendall in the Word Processing Center; Bob Davis in the Art Department, with special appreciation to artists, Wilna Tannahill, Kim Hale, Candy Haun, Colin McLain, Suzanne Morris, Robert Randall, David Thompson, Gary Bradley, Kathryn Moore, and Clay Dorrell; Noel Wilcoxson, Duane "Frosty" Foster, and Diane Ensign and their staffs at the ODVTE Print Shop; Karen Williams and her staff in the Resource Center, especially Denise Dow, for their assistance in obtaining resources for this publication.

And finally, a very special acknowledgement goes to Chuck Pendergast, the technical advisor for this project, without whose expert collaboration, advice, support, review, and encouragement this curriculum would not have been possible.

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USE OF THIS PUBLICATION

INSTRUCTIONAL UNITS

Electrical Systems Specialist contains nine units. Each instructional unit includes basic components that form a unit of instruction: performance objectives, suggested activities, pretests, pretest answers, information sheets, assignment sheets and their answers or job sheets and their practical tests, written tests, and written test answers. Handouts, supplements, transparency masters, and activity sheets are optional components which may be included in some or all of the units. Transparency masters, handouts, pretests and written tests are included in the instructor edition only and may be duplicated for classroom use. Test packets may be purchased in Oklahoma by calling 800-522-5810. Out-of-state instructors may order test packets by calling 800-654-4502.

The unit components focus on measurable and observable learning outcomes. When applicable, units include activities that use the affective domain. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. By carefully studying each unit of instruction, the instructor will be able to plan presentations and demonstrations to meet the needs of the students as well as determine the following:

- How to use the materials for independent study
- Amount of material to cover in a single class period
- Skills that must be demonstrated
- Supplies and equipment needed
- Amount of class time for demonstrations
- Amount of class time for student practice
- Supplementary materials to order, such as pamphlets, videos or software
- Resource people to contact

Objective Sheets (White Pages)

Each unit of instruction is based on the knowledge and skills needed for successful employment in an occupational area. What the student must know and be able to do has been translated into performance objectives which are stated in two forms. **Unit objectives** state the subject matter to be covered in a unit of instruction, what the student should be able to do and what standard will be used to determine whether the student has achieved competency. **Specific objectives** outline the teaching sequence and state the performance necessary to meet the unit objective.

The objectives can also help determine teaching strategies and instructional methods. Instructors will need to decide how each objective can best be taught (individualized or class instruction) to *their* students prior to teaching the unit. Instructors should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. If objectives are added, the instructor should remember to supply the needed information, assignment sheets, job sheets, and criterion test items.

Suggested Activities (Pink Pages) — **Instructor's Edition Only**

This component assists the instructor during the preparation stage of the teaching/learning process by providing suggestions for delivery, enrichment, and application during the instructional process. Teaching suggestions are included for each objective. The instructor should read the suggested activities before teaching the units to allow time to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the instructor will vary according to the particular unit.

Included in this component are suggested resources of additional information audiovisual materials, and software which may be used to teach the unit. Unit references used in the development of each unit are also provided. Instructors can use suggested resources and unit references to supplement their knowledge of the subject or to help students with particular interests or occupational objectives in the subject area.

Handouts (White Pages) — **Instructor's Edition Only**

Handouts are additional teaching aids that support portions of the information sheet by providing "nice-to-know" information which is not testable. They may include activities such as games, puzzles or supplementary information on subjects that are considered to be controversial. The instructor may decide whether to duplicate and use handouts in teaching the unit.

Pretests (Yellow Pages)

Because students bring a variety of background experiences and knowledge to the classroom, pretests are included to allow the student the opportunity to demonstrate previously gained information. The pretest provides a criterion-referenced tool for evaluating students' knowledge prior to studying the unit. For a description of this component, please refer to the written test description.

Pretest Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on written tests.

Information Sheets (Green Pages)

The information sheets provide "must know" content that is essential for meeting the cognitive objectives. The information sheets serve as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Space is provided in margins for students and instructors to add notes that supplement, localize, personalize, or provide motivation for each unit. Program coordinators, directors and/or instructors are encouraged to select and require textbooks for students in order to supplement and expand the material covered in the information sheets.

The information sheets may include notes, cautions, or warnings. These should be discussed carefully and thoroughly. **Notes** are short verbal additions to the information that provide nice-to-know and decision-making information. A note may tell the student what to look for or consider at a given step, or may explain when a step may not be applicable. Notes offer guidance that may help the student understand the process and accomplish it more efficiently. **Cautions** are advisories that alert students to possible dangers to themselves or others. **Warnings** are advisories that alert the student to possible danger to equipment or facilities.

Supplements (Green Pages)

Supplements include material that provides additional information for understanding the topic but may not have direct application to specific objectives. Instructions that might be used for solving problems, tables, charts, written information, forms, or other information students might need in order to complete one or more of the assignment or job sheets could be included as a supplement. While supplements are not tested over directly, they may be used to assist the student in meeting the performance objectives.

Transparency Masters (White Pages)—**Instructor's Edition Only**

Transparency masters provide information in a special way. They direct attention to the topic of discussion and allow the instructor to illustrate the topic. The use of transparencies is especially effective for visual learners who prefer to see the topic being presented as well as hear about it. Transparencies may present new information or they may reinforce information presented in the information sheets. Transparencies should be made ahead of time and placed with the rest of the materials necessary to teach the unit.

Activity Sheets (Tan Pages)

Activity sheets provide activities which support several objectives or deal with students' attitudes, beliefs or appreciation of the study area. Some may ask rather personal questions and are only intended for each student's personal use while other activity sheets may require the student to monitor his or her own actions or other personal variables over a period of time. Activity sheets will vary greatly in their design from unit to unit. Answer sheets may or may not be provided.

Assignment Sheets (Tan Pages)

Assignment sheets provide written exercises for instruction and practice of a specific objective. The introduction to the assignment sheet explains how the assignment sheet relates to the subject area and unit objectives and may provide instructional information or refer students to another component for such information.

Assignment sheets are intended to provide students with practice in exercising higher-order thinking skills. Often, assignment sheets will contain case studies, story problems, or other situations in which the student must analyze the circumstances and determine correct responses. Students may be given assignment sheets in class or as homework.

Assignment Sheet Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on assignment sheets.

Job Sheets (Blue Pages)

Job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure to complete each task or job. Diagrams, photographs, and illustrations may be included to assist students in achieving the skill.

The instructor should demonstrate the procedures outlined in each job sheet. Furthermore, the instructor needs to localize the procedure according to the equipment and supplies available in the local lab situation. Job sheets also show potential employers what skills the students are learning and the performances they might reasonably expect from students who have had this vocational instruction.

Practical Tests (Yellow Pages) — **Instructor's Edition Only**

The practical tests assist the instructor in evaluating the psychomotor activities (Job Sheets). They provide instructors with a valid mechanism for determining a student's level of ability to perform the procedure stated on the job sheet and a means of evaluating the student's final product.

Written Tests (Yellow Pages) — **Instructor's Edition Only**

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. All performance objectives, including those in the information sheets, assignment sheets, and job sheets must be evaluated. If objectives have been added, deleted, or modified, appropriate changes should be made on the test.

The tests may be written or oral. It may be advisable to divide the tests into shorter tests covering three or four objectives at a time and give them soon after those objectives are covered.

The acceptable response on a written test, eighty-five (85) percent in most units, applies to the overall score, not to each individual question. The final unit grade should be obtained by combining written test and assignment sheet scores with evaluation ratings for students' demonstrations of tasks.

Written Test Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on written tests.

PAGE NUMBERING

Each CIMC publication is assigned a specific abbreviation or can be recognized by the book title. *Electrical Systems Specialist* will be referred to by "ESS." Each unit is identified by the unit number in Roman numerals followed by the page number. The first page of each unit is always page 1. The component name, book title, unit number, and page number within the unit are printed at the bottom of each page. An example of the page footer for an objective sheet in *Electrical Systems Specialist* is shown below.

OBJECTIVE SHEET - ESS
I - 1

METHODS OF DISSEMINATING MATERIAL

Each student should be provided with a student workbook. Workbooks may be purchased for less than an instructor can reproduce them, especially when the instructor's time is considered. Student workbooks contain everything but the suggested activities, handouts, transparency masters, assignment sheet answers, tests, and test answers. Test packets may be purchased from the Curriculum and Instructional Materials Center. Students should be allowed to take their workbooks home when they complete the program.

TEACHING METHODS

It is a challenge to keep students motivated. Instructors can supplement the objectives by providing the "why", personal experiences, and current information. Preparation for each unit should be determined by how each objective can best be taught. Students should become involved in preparing and planning for each unit.

If the material will be utilized in an individualized instruction situation, instructors should provide opportunities that will allow students to become involved in planning for and being responsible for their own education.

COMPETENCY PROFILES

A competency profile is available for each CIMC publication. Competency profiles document student performance. The profile contains a list of the specific job competencies that a student should achieve before leaving the training program. Profiles should be distributed to students as needed.

DISCLAIMERS, CORRECTIONS AND SUGGESTIONS

Materials

Please note that suggested resources and references listed in this publication existed when this publication was written. CIMC assumes no responsibility for providing these materials and cannot ensure the availability of these materials as individual vendors, manufacturers, and publishers may discontinue these products at any time.

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The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. The CIMC assumes no responsibility for any adverse effects resulting directly or indirectly from the information, suggested procedures, undetected errors in or the reader's misunderstanding of the information presented.

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To ensure that the material is updated on a timely basis, notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

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Attn: Curriculum Development Coordinator
Oklahoma Department of Vocational and Technical Education
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BASIC SKILLS IN CIMC MATERIALS

Preparing students to enter successfully into today's world of work offers vocational education a substantial challenge. The contemporary workplace is characterized by constant and rapid technological change and by increasing job complexity and skill intensity. Due to rapid technological advancement, the half-life of work skills is now reduced to a bare three to five years. Out of this new workplace environment has arisen a growing awareness of the critical importance of an American workforce armed with the skills necessary to survive in a competitive economy.

One result of this national awareness has been the emergence of a renewed emphasis on basic academic skills in all areas of education. Pressure to increase academic skill development is being placed on education by both legislative action and industry mandate. The Carl D. Perkins Vocational and Applied Technology Education Act of 1990 sets stringent basic skill requirements for vocational education. State legislatures are increasingly requiring basic skills accountability by teachers and school administrators. Graduation exams, minimum competency requirements, and expected learner outcomes are being implemented with increasing frequency. In addition, business and industry are delivering the message clearly to educators that vocational competence now requires increased strength in the basic skills.

The issue of the basic skills currently required in the work place was very successfully addressed in a recent national three-year study conducted jointly by the American Society of Training and Development (ASTD) and the U.S. Department of Labor (DOL). The findings of this study were published in 1990 in the book, *Workplace Basics: The Essential Skills Employers Want.*

The ASTD/DOL research indicates clearly that American employers have discovered that their workforces need a variety of skills that include, but are not limited to, the classic academic trio of reading, writing, and computation. Employers now are also looking for competence in areas such as "learning to learn," problem solving and critical thinking, interpersonal and teamwork skills, oral communication and listening techniques, and the social and personal management skills that demonstrate a capacity for independence and responsibility in on-the-job performance.

It is clear that the requirements of today's business and industry have expanded and re-defined "workplace basics." It is in line with the re-definition and with the competency requirements of current education legislation, that the Oklahoma Department of Vocational and Technical Education has chosen to address "basic skills" in the instructional materials produced by its Curriculum and Instructional Materials Center.

It is not a new development for CIMC materials to contain information and activities which develop basic skills competencies in students undertaking vocational programs. What is new is the specific marking, or flagging, of items in our instruction materials that address basic skills.

To assist teachers and students in identifying activities which promote basic skills development, CIMC has implemented a marking system which uses simple graphic symbols or icons. These icons are located in the left margins of assignment sheets, activity sheets, and job sheets. The following is an explanation of the icons and the kinds of basic skill activities they indicate.

1. **READING SKILLS:** Skills involving use of print resource material for obtaining and applying information.

Current vocational education literature indicates that functional literacy as a workplace basic needs to be defined in terms of reading competencies actually required for job performance. The activities identified with this icon addressing reading skills in CIMC materials deal specifically with developing reading skills in an applied, job-related context. These range from general information-gathering activities to tasks requiring use of specific technical reference materials. Many contain a "learning to learn" aspect which promotes engaging actively and purposefully in vocationally relevant inquiry.

2. **WRITING SKILLS:** Skills involving written communication of processes, information, or ideas.

Tasks identified with this icon promote development of skills in written communications. As with reading skills, the writing skills emphasized in CIMC materials have a vocational context. They include filling out forms, keeping work activity records, writing simple memos and letters, generating more complex reports and articles, and written expression of ideas and concepts related to vocational performance or exploration.

3. **MATHEMATICS SKILLS:** Skills involving computation, calculation, and interpretation of numerical data.

This icon identifies activities which develop vocationally-related skills in computation, measurement and estimation, selection and application of appropriate mathematical processes, and collecting, displaying, or interpreting data.

4. **SCIENCE SKILLS:** Skills involving mastery and application of scientific information or theory.

This icon marks activities which are related to the development of skills in either the physical or biological sciences. These skills stress occupationally-related application of science and technology.

5. **ORAL COMMUNICATION SKILLS:** Skills involving speaking and listening.

Activities marked with this icon promote development of effective speaking and listening. They include practice in such areas as speaking techniques, word choice, non-verbal messages, use of communication media, and using active listening techniques. Many of these activities promote "learning to learn" skills in verbal inquiry.

6. **INTERPERSONAL OR RELATING SKILLS:** Skills involving working and getting along with others.

Activities which deal directly with skills in relating to others are marked with this icon. This includes areas such as multi-cultural awareness, group processes and dynamics, negotiation, dealing with conflict, cooperation and teamwork, values and attitudes, and leadership and motivation.

7. **CREATIVE THINKING AND PROBLEM SOLVING SKILLS:** Skills involving comprehending, applying, analyzing, and developing complex ideas and situations.

This icon identifies activities which stress development of higher-order thought processes such as problem identification and analysis, lateral thinking, evaluating alternatives, developing solutions, examining assumptions, and evaluating outcomes.

8. **EMPLOYABILITY SKILLS:** Skills involving choosing, obtaining, and succeeding in a career.

Activities marked with this icon relate to competencies required to obtain employment and develop a career. These competencies include specific occupational tasks. They also include items such as career analysis and selection, job searching, completing applications and resumes, interviewing, business etiquette, and personal management skills required for job-keeping and maturing in one's work. Examples of the later category include personal presentation, self-discipline, work accuracy, reliability, discretion, punctuality, handling stress, judgment, confidence, etc.

9. **SOCIAL STUDIES SKILLS:** Skills involving investigation and application of social concepts.

This icon marks activities which stress competencies in fields relating to human society and its distribution and relationships. This includes areas such as history, geography, demographics, current events, cross-cultural studies, consumer issues, environmental issues, and ethical concerns in science and technology.

Some activities in CIMC materials develop skills in more than one of the eight basic skill areas. In cases where the relative strengths of the skill elements are clearly discernable, the identification icon used is the one judged to be the primary, or strongest, element in the activity. For some activities, more than one icon is used, indicating equal strength of basic skills components in the activity.

The use of graphic icons to identify basic skills in CIMC instructional materials is the first in a series of steps designed to foster basic skills development in vocational students and accountability for vocational teachers. The Oklahoma Department of Vocational and Technical Education has developed a staged implementation strategy for integrating basic skills into CIMC materials. Additional basic skill elements in future CIMC publications will reflect the advancement of this staged implementation

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OBJECTIVE SHEET

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

INTRODUCTION

Only two wires are needed to run an automobile: one from the battery to the coil and one from the battery to ground. Such a car would have little in common with today's automobiles, though. It would have to be cranked to start, and would lack required safety features such as headlights, and comfort systems like the radio or dome lights.

Basic systems, safety features, and comfort accessories all rely on electrical circuitry. The increased use of electrical elements has been a major development in automotive design through the years. Understanding the scope and function of electrical parts, components, and systems is important for any service specialist and will continue to grow in importance in the future.

PREREQUISITES

The student should have successfully completed all units of "Introduction to Automotive Services" or other basic curriculum.

UNIT OBJECTIVE

After completing this unit, the student should be familiar with basic electrical components and systems, test equipment, types of faults, protection devices, and types of circuits. The student should be able to determine wire gauge needed, diagnose causes of battery drain, interpret wiring diagrams, find shorts and grounds, and inspect, test, and replace circuit protection devices. The student will demonstrate these competencies by completing assignment sheets, job sheets, and a written test with a minimum accuracy of 85 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with diagnosing electrical system repair to their definitions.

2. Select from a list basic electrical components.

3. List basic electrical systems.

4. Describe common electrical tools and test equipment.

5. Distinguish among types of electrical faults.

6. Label circuit protection devices.

7. Read and use wiring diagrams. (Assignment Sheet 1)

8. Determine wire gauges. (Assignment Sheet 2)

9. Interpret wiring diagrams. (Assignment Sheet 3)

10. Diagnose causes of battery drain. (Assignment Sheet 4)

11. Determine types of circuits and the effect of faults. (Assignment Sheet 5)

12. Demonstrate the ability to

    a. Identify circuits in various vehicles. (Job Sheet 1)

    b. Find shorts and grounds. (Job Sheet 2)

    c. Inspect, test, and replace circuit protection devices. (Job Sheet 3)

SUGGESTED ACTIVITIES

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

- Review teaching suggestions given in the "Delivery" section and plan classroom activities. Also note suggestions for media and supplemental materials.

- Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the "Suggested Resources" section. Include in your selection media that demonstrate job-sheet skills. Videotape your own demonstrations of job-sheet procedures if unable to obtain suitable media.

- Prepare classroom and shop. Display posters, charts, safety signs, illustrations, tables, and reference materials.

- Discuss with students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment-sheet competencies and job-sheet skills as part of the pretesting process.

- Assess student competencies. Consider results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss introduction to the unit (see Unit Objective).

- Discuss the unit objective and then the specific objectives. Emphasize that electrical systems are becoming complex and stress the increased need to understand the electrical and electronic functions in today's cars for home or professional auto repair.

- Review basic safety and first aid, especially relating to fire and electricity. Relate the materials to previous instruction.

- Review basic electrical facts. Define amps, volts, ohms, current, circuit, etc. and discuss their relationships and functions.

- Discuss the number of electrical or electronic parts, components, and systems in today's automobiles. Have students name or list as many as they can to demonstrate how important electrical and electronic diagnosis and repair is.

- Invite a salesman or factory-trained mechanic to discuss future electrical/electronic systems.

- Explain the difference between electrical and electronic. Give examples other than automotive (i.e., electric vs. electronic typewriters).

Objective 1 Match terms associated with diagnosing electrical system repair to their definitions.

- Review pertinent terms and definitions in the core curriculum.

- Add to the list of terms any basic definitions students have not mastered, according to pretest results.

Objective 2 Select from a list basic electrical components.

- Compare similarities between electrical components.

- Review the purpose of each major component.

- Have students examine a repair manual and list all electrical components they find.

- Be certain that students understand that electrical components can be large or small. Base their concept of "component" on how it can be serviced—inspected, tested, or maintained, as well as being replaced.

Objective 3 List basic electrical systems.

- List basic electrical systems and review their function and relationship with other systems.

- Explain that some manuals will list other systems, particularly when discussing comfort systems.

- List major components in each system. These will be covered in detail later in the curriculum.

Objective 4 Describe common electrical tools and test equipment.

- Refer to the core curriculum for detailed instructions on how to use some of these basic tools. Review these procedures and allow students to use the tools.

- Provide examples of digital and analog meters and have students use both.

- Have students use a multimeter as a voltmeter, ohmmeter, and ammeter. Provide examples of other combined instruments as available.

- Avoid introducing electronic test equipment, which will be covered in Unit II.

- Present photos and examples of test equipment not listed in this unit, as available.

Objective 5 Distinguish among types of electrical faults.

- Explain the outcome of each type of fault on each type of circuit.

- Discuss how the fault location within a circuit will affect the system.

- Be sure students understand how these function, both as a planned element of a circuit and as a fault.

- Have students complete Assignment Sheets 1-5 and Job Sheets 1 and 2.

- Refer to the core curriculum for related exercises.

Objective 6 Label circuit protection devices.

- Show students examples of each protection device. Show them where these are usually found and have them locate one of each on their own cars.

- Have students determine the correct replacement for the protection devices they located on their cars. Have them use repair manuals and/or owner's manuals to find the proper replacement size and number. Show them where on their protection devices these numbers are located.

- Have students complete Job Sheet 3.

- Refer to the core curriculum for previous related exercises.

APPLICATION

Objective 7 **Read and use wiring diagrams** (Assignment Sheet 1).

Objective 8 **Determine wire gauges** (Assignment Sheet 2).

- Have students test the flow of electricity through wiring of various gauges and lengths to see how these affect the amount of current traveling through the wire.

- Explain to students that there are several measurements to consider here. At the source, the wire receives current measured in volts. What it passes the current to will measure current in amps. The wiring itself will be chosen according to its resistance, in ohms.

- Refer to the core curriculum for previous related exercises.

Objectives 9 **Interpret wiring diagrams** (Assignment Sheet 3).

- Encourage students to study repair manuals for various types of cars. Have them note differences in diagrams published by different manufacturers.

- As students trace circuits, have them identify loads, fusible links, fuses, switches, circuit breakers, etc. Have them identify each circuit as being series, parallel, or series-parallel.

Objective 10 **Diagnose causes of battery drain** (Assignment Sheet 4).

- Discuss the parasitic loads of the new electronic computer on battery drain. Explain that, although these drain so little power they have no obvious effect, their function must be considered. For example, in some cars, removing the battery for testing may shut down the computer. This may lead to additional repair.

- Be sure students understand that a battery does not store energy, but rather, that it converts chemical energy to electrical current.

- Review the three major functions of a battery: 1) to supply current necessary to start the engine, 2) to supply current when the charging system cannot meet demand, and 3) to stabilize voltage within the system during operation.

- Refer to the core curriculum for previous related exercises.

Objective 11 **Determine types of circuits and the effect of faults** (Assignment Sheet 5).

- Explain to students that circuitry can be intricate, but is always one of three basic circuit types.

- Have students use schematic drawings of various electrical systems to identify more complicated versions of these circuit types.

- Refer to the core curriculum for previous related exercises.

Objective 12a **Identify circuits in various vehicles** (Job Sheet 1).

- Have each student describe the consequences of a short, ground, or open circuit at various locations throughout the circuit.

- Refer to the core curriculum for previous related exercises.

Objective 12b **Find shorts and grounds** (Job Sheet 2).

Objective 12c **Inspect, test, and replace circuit protection devices** (Job Sheet 3).

- Stress safety during these exercises.

- Discuss the type of circuit and why it was affected as it was.

- Have students diagnose the cause of the fault.

- Have students name at least one other method of diagnosing the fault.

- Refer to the core curriculum for previous related exercises.

Unit summary activity

- Discuss questions students may have.
- Give written test.
- Give practical tests, and evaluate tests on forms provided.
- Complete appropriate section of competency profiles.

EVALUATION

Pretest

- Pretest qualifying students.
- Determine individual requirements from pretest results.
- Counsel students individually on pretest results and study requirements.
- Modify materials in unit or create supplementary materials for individual students as required.

Practical test

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.
- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.
- Complete appropriate section of competency profiles.

- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Publications

- *Automotive Electronics.* Ten units of instruction and a set of transparencies review AC and DC electronics, including semiconductors and digital electronics with hands-on use of test equipment, emphasizing oscilloscopes. The book provides information on microprocessor architecture and computerized engine controls, testing sensors, and troubleshooting sensor interaction. Procedures include using equipment required for troubleshooting diagnostic codes; working with troubleshooting trees, and diagnosing driveability problems on specific vehicle models. Order Nos.: Teachers' Guide, 602301; Student Manual, 602302; Transparency Set, 602303. Available from MAAVC, 1-800-654-3988.

- *MOTOR Auto Engine Tune Up & Electronics Manuals, Wiring Diagram Manuals, Component Locator Manuals, Handbooks, and MOTOR MAGAZINE.* Updated annually. Contact MOTOR Publications, c/o Betty Strong, P.O. Box 72001, Oklahoma City, OK 73172, phone (405) 721-0310.

Computer Software

NOTE: The following programs are available from Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, telephone 1-800-645-3565 (all states except New York) or 1-800-645-1737 (all states).

- *Basic Electricity and Electronics: Direct Current.* One diskette, one back-up, and a courseware guide are available with each of the four programs in this series designed to be used with an Apple II computer (48K). Topics included in each program are listed below. Programs may be purchased individually or as a set. The order number for the entire set is E12. Order numbers for the individual programs are listed below.

  Program 1: "Electron Flow" discusses atomic structure, current, voltage, resistance, abbreviations, basic formulas, and Ohm's law.

Program 2: "Symbols, Diagrams, and Circuits" covers symbols and diagrams, wiring circuits, ammeters, voltmeters, wiring tools and diagrams, and safety.

Program 3: "Ammeters and Voltmeters" concerns reading and using analog and digital meters.

Program 4: "Ohm's Law in Action" Discusses relationships between amps, volts, and ohms.

- *Fundamentals of Automotive Electricity*, order number AA51-V9. This computer program includes high-resolution graphics, animation, interactive questions, and unit quizzes with printable results. Program comes with a courseware guide and includes six copies of the program disk. Topics covered by the program are the electron theory (solar system atom construction, insulators and conductors, electron theory), units of electricity (voltage, amperage, resistance, ohm's law), simple circuits (complete circuit, schematic symbols, open and short circuits, series circuits, voltage drops, parallel circuits, series-parallel circuits).

Audio Visuals

NOTE: The following programs are available from General Motors Training, Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28635 Mound Road, Warren, MI 48092, 1-800-468-6657.

- *Fundamentals of Automotive Electricity.* Uses text, animation, and graphics to explain electron theory, units of electricity, and simple circuits. One double-sided disk and six copies for Apple, 48K. Order No. 059-671, available from Career Aids Division, Opportunities for Learning, Inc., 20417 Nordhoff St. Dept. IN5, Chatsworth, CA 91311, phone (818) 341-2535.

- *Troubleshooting with the VAT-40*, order number 441-X. This five-program series can be purchased in a five-filmstrip/five cassette (11 to 14 minutes each) version with a study guide. Produced in cooperation with the Sun Electric Company, topics included in each program are listed below.

Program 1: "Introduction and Meter Reading." Topics covered are how to identify starting and charging-system problems, connection procedure, meter use, and interpretation of meter readings.

Program 2: "Performing System Tests." Topics include demonstrations-of five go/no go tests, battery performance, starting system, charging system, regulator, and diode stator.

Program 3: "Testing Battery Performance." This program describes how to load test a battery, locate all battery problems, and evaluate the power-output capability of the charging system.

Program 4: "Troubleshooting the Starting System." This program demonstrates how to perform circuit-resistance tests for insulated, ground, and switch circuits and how to locate excessive voltage drops across connections and cables.

Program 5: "Troubleshooting the Charging System." This program shows how to perform in-car tests of the alternator and generator, how to perform regulator-bypass tests, how to locate excessive voltage drops in charging circuits, and how to perform circuit-resistance tests.

- *Electricity for Auto Technicians* is a 5-part video tape series (approximately 15 minutes each) corresponding to the NATEF Task list, designed for use in ASE certification programs.
  - *What is Electricity?* discusses electron theories, magnetism conductors, and insulators.
  - *Measuring Electricity* presents Ohm's laws and discusses measurements.
  - *Electricity In the Car* covers wiring diagrams, solenoids, relays, series and parallel circuits, and basic systems.
  - *Test Equipment* demonstrates use of common test instruments.
  - *Electrical Troubleshooting* explains diagnosing basic faults and battery maintenance.

NOTE: The following programs are available from General Motors Training, Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28635 Mound Road, Warren, MI 48092, 1-800-468-6657.

- *Electricity/Theory and Basic Circuitry*, order number GM-18001-001, covers electrical fundamentals, magnetism, Ohm's law, basics of circuitry and test equipment.

- *Electrical Diagnosis Simplified*, order number GM-18001-011, review electrical basics, and explains troubleshooting procedures.

NOTE: The following programs are available from Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050.

- *Basic Electrical Theory and Test Equipment*. Order number 31275-169. This twelve-part filmstrip or sound-slide from Hoffman Information Systems productions stresses the concepts and applications related to automotive systems and standard testing devices. Titles of each of the twelve programs are listed below.

  "Basic Electron Theory"
  "Principles of Magnetism"
  "Voltage"
  "Current"
  "Resistance"
  "Electrical Circuitry"
  "How to Read Electrical Wiring Diagrams"
  "Introduction to Electrical Testing Devices"
  "Use of the Voltmeter"
  "Use of the Ohmmeter"
  "Use of the Tach-Dwell Panel"
  "Volt-Amp Tester Hookup"

Media

NOTE: The following transparency masters are available from DCA Educational Products Inc, Kellers Church Road, PO Box 338, Bedminister, Pennsylvania 18910.

- DCA produces six groups of transparencies in a 60-transparency "Auto Engine Systems" series with 42 overlays, an instructor's guide, and a library case. Titles of the six groups include "Engine Mechanical Systems," "Lubrication and Cooling Systems," "Fuel, Induction and Exhaust Systems," "Engine Electrical Systems," "Engine Tune-Up" and "Emission Control Systems." Order number for the series is AES000, but individual groups may be purchased separately. Group 4, "Engine Electrical Systems," includes transparencies on electricity, magnetism, typical electrical systems, battery construction, visual battery checks, battery tests, starter construction, starting system tests, alternator construction, and charging system tests.

NOTE: The following filmstrips are available from NIMCO, National Innovative Media, Route 2, Box 3018, Calhoun, Kentucky 42327, telephone 1-800-962-6662 (all states except Kentucky). Each set includes one cassette, one filmstrip, and one worksheet.

- *Battery Testing*, MSJ-AT-M-12A.
- *Battery Servicing*, MSJ-AT-M-12B.
- *Electron Theory*, MSJ-AT-M-2A
- *Ohm's Law*, MSJ-AT-M-2B
- *Electrical Circuits*, MSJ-AT-M-2C
- *Voltmeters and Ammeters*, MSJ-AT-M-6A
- *Ohmmeter*, MSJ-AT-M-6B

UNIT REFERENCES

Resources used in developing unit

- *Bronco/F150-F350 /F-Super Duty Electrical and Vacuum Trouble-Shooting Manual*. Ford Motor Company, 1988.
- *Celebrity Electrical Diagnosis Service Manual, 1988*. General Motors.
- deKryger, et al. *Auto Mechanics, Theory and Service*. West Chicago, Illinois: South-Western Publishing Co., n.d.
- Downing, Ron. *Auto Body Repair Curriculum Guide*. South Holland, Illinois: Goodheart-Willcox Co., Inc., 1985.

- Duffy, James. *Auto Electricity, Electronics, Computers.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1990.

- *Electrical Service and Repair: Domestic Cars.* San Diego, California: Mitchell International, Inc., 1987.

- *Fundamentals of Electronics and Semi-Conductors.* Benton Harbor, Michigan: Heath Company, 1985.

- General Motors Corporation, *1990 Electrical Diagrams and Diagnosis Manual: C-K Truck Models.* U.S.A.: General Motors Corporation, 1989.

- Mackert and Heiserman. *Automotive Electronics*, Teacher's Guide.

- Todboldt, William K. and Johnson, Larry. *Automotive Encyclopedia: Fundamental Principles, Operation, Construction, Service, Repair.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1983.

PRETEST ANSWERS

ELECTRICAL SYSTEM REPAIR REQUIREMENTS I

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1, 2, 3, 4
2	5
3	41
4	6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
5	21, 22, 23, 24, 25, 26, 27, 28, 29
6	28, 30, 31, 32
7	33, 34, 35
8	25, 27
9	36
10	37
11	38, 39, 40

ANSWER KEY

1. b
2. a
3. c
4. a
5. c
6. a
7. c
8. b
9. b
10. a
11. c
12. b
13. a
14. a
15. b
16. c
17. a
18. b
19. b
20. a
21. a
22. b
23. c
24. c
25. a
26. b
27. c
28. a
29. c
30. b
31. b
32. c
33. a
34. b
35. a
36. c
37. b
38. a

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

Name ______________________ Score ________

DIRECTIONS Circle the letter in front of the correct answer.

1. The symbols "A" and "I" in Ohm's law represent ______.

   a. ohms
   b. amps
   c. volts

2. The symbols "R" and "Ω" in Ohm's law represent ______.

   a. ohms
   b. amps
   c. volts

3. Two of the symbols representing volts are "V" and ______.

   a. "A"
   b. "Ω"
   c. "E"

4. An ampere measures ______.

   a. the number of electrons passing a given point
   b. the amount of electrical pressure in a circuit
   c. the amount of resistance in a circuit

5. Examples of electrical components are ______.

   a. battery cables, terminals, and posts
   b. regulator, tachometer, and battery
   c. multimeter, jumper wire, and ohmmeter

6. An ammeter is connected in ______.

   a. series
   b. parallel
   c. inverse

7. To use a conventional ammeter a circuit must be ______

   a. powered
   b. series
   c. broken

8. An inductive ammeter is ______.

   a. connected to the circuit in series
   b. clipped over the wire insulation
   c. rarely used

9. A continuity test light ______.

   a. measures resistance
   b. shows if voltage is present
   c. becomes brighter if voltage is increased

10. A self-contained test lamp includes ______.

   a. a battery, bulb, and two leads
   b. two clamps and a copper lead
   c. one lead and a digital readout

11. If a self-contained test lamp is connected to two points of a circuit and the light comes on, you know ______.

   a. the circuit contains a short between the two points
   b. the circuit has blown a fuse between the two points
   c. there are no faults in the circuit

12. A jumper wire creates ______.

    a. a series circuit
    b. a parallel circuit
    c. a ground

13. The most commonly-used circuit analysis and testing tool is the ______.

    a. multimeter
    b. ohmmeter
    c. ammeter

14. A multimeter measures ______.

    a. voltage, current, and resistance
    b. voltage, gauge, and current
    c. gauge, current, and resistance

15. The two types of multimeters are ______.

    a. AC and DC
    b. analog and digital
    c. manual and automatic

16. Before using a multimeter ______.

    a. the function must be chosen
    b. the range must be determined
    c. both a and b

17. If continuity is good ______.

    a. resistance is low
    b. voltage is low
    c. amperage is low

18. If a voltmeter has a red lead and a black lead, the user should ______.

a. connect the red to ground, the black to a lead
b. connect the black to ground, the red to the measuring point
c. connect the red to the measuring point, the black to a lead

19. A ground ______.

a. opens a circuit
b. completes a circuit
c. disconnects a circuit

20. A ground occurs when ______.

a. copper touches iron
b. copper touches copper
c. iron touches iron

21. When a ground occurs ______.

a. no loads past the ground receive power
b. no loads in the circuit receive power
c. no loads before the ground receive power

22. Shorts occur when ______.

a. copper touches iron
b. copper touches copper
c. iron touches iron

23. A short in a series circuit means ______.

a. the circuit is closed
b. nothing after the short will receive power
c. nothing in the circuit will receive power

24. Open circuits are ______.

a. always intentional
b. always unintentional
c. either intentional or unintentional

25. In a parallel circuit, an open in one path will ______.

a. not affect the other paths
b. open all paths
c. result in a short circuit

26. Blown fuses result in ______.

a. closed circuits
b. open circuits
c. series circuits

27. High resistance in a circuit can be caused by ______.

a. improper wire gauge
b. loose connections
c. both a and b
d. neither a nor b

28. Fuses blow when ______.

a. excessive current flows through the circuit
b. current is interrupted
c. resistance increases

29. A fusible link ______.

a. connects fuses to the circuit
b. connects fuses
c. works just like a fuse

30. When an open circuit breaker cools, ______.

a. it must be replaced
b. it closes and completes the circuit
c. it causes a short

31. Resistance is increased as ______.

a. voltage is increased
b. area of conductor is decreased
c. the system ages

32. Gauge of wire is determined by ______.

a. the thickness of the wire with insulation
b. the thickness of the insulation
c. total area of wire

33. The best choice for wire gauge used is ______.

a. the smallest gauge possible without compromising safety
b. the largest gauge possible without compromising safety
c. gauge really doesn't matter

34. Some possible causes of a discharged battery are ______.

a. vehicle driven too much
b. loose or corroded battery or alternator connections, defective alternator or battery, loose or worn belt drive
c. turn signals operating too quickly

35. When using a diagram of an electrical system, it is usually better to go ______.

a. from voltage to load
b. from the dashboard switch to the load
c. alphabetically through the wires

36. Tools used to check for continuity are ______.

- a. hydrometer or ohmmeter
- b. jumper wire or ammeter
- c. tilt light or ohmmeter

37. If a voltmeter connected to a good ground and to a lead past a fusible link registers voltage, ______.

- a. the link is blown
- b. the link is good
- c. a short exists

38. Splice clips are placed ______.

- a. over stripped wire, with exposed metal extending from each end of the clip
- b. over stripped wire, covering the edge of the insulation
- c. over soldered and taped wire

INFORMATION SHEET

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

OBJECTIVE 1

Match terms associated with diagnosing electrical system repair to their definitions.

- **Ampere (Amp, A, or I)** — A unit of measure of the amount of electrical current; the number of electrons flowing past a given point per second
- **Circuit** — A combination of components connected to form a pathway through which electrons can flow
- **Electrical** — Powered by a flow of electricity through conductors, usually wire, that produces heat or heat and light
- **Lead** — A piece of wire carrying current
- **Load** — A circuit component that converts electrical energy to some other form of energy, (i.e., mechanical energy, heat)
- **Ohm (Ω or R)** — A unit of measure of resistance; the amount of opposition offered to the flow of electrons by the substance through which it is passing
- **Volt (V or E)** — A unit of measure of the amount of electrical pressure causing electrons to flow

  NOTE: Watt is a term used to describe the rate of electrical discharge.

OBJECTIVE 2

Select from a list basic electrical components.

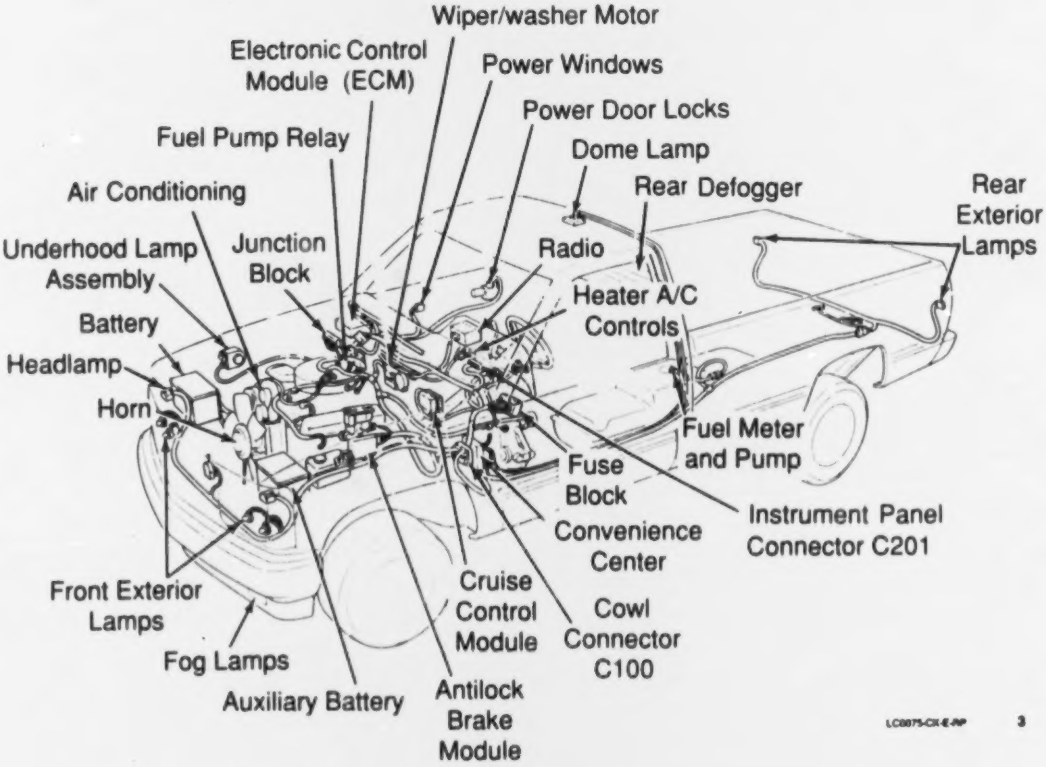
NOTE: Electrical components are groups of connected parts designed to perform a specific but limited function within a system through the use of electrical currents. Components are usually contained in a housing. Service of components includes inspection, testing, and maintenance, as well as replacement.

- Battery
- Starter
- Voltage regulator
- Alternator or generator

- Lighting system flashers and switches
- Warning indicator sensors, switches, indicator modules, and buzzers or chimes
- Driver information gauges such as the tachometer or coolant temperature gauge
- Washer pump, washer/wiper switch, and wiper motor assembly
- Power window switches and motors
- Horn, lighter, radio, clock, etc.

NOTE: This is a list of major components we will cover. Other components may be found in any vehicle, as illustrated in the diagram below.

FIGURE 1


Wiper/washer Motor
Electronic Control Module (ECM)
Power Windows
Power Door Locks
Fuel Pump Relay
Dome Lamp
Air Conditioning
Rear Defogger
Rear Exterior Lamps
Underhood Lamp Assembly
Junction Block
Radio
Heater A/C Controls
Battery
Headlamp
Horn
Fuel Meter and Pump
Fuse Block
Instrument Panel Connector C201
Convenience Center
Front Exterior Lamps
Cruise Control Module
Cowl Connector C100
Fog Lamps
Auxiliary Battery
Antilock Brake Module
LC0075-CX-E-NP
3

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OBJECTIVE 3

List basic electrical systems.

NOTE: An electrical system is a group of connected electrical components which function together to accomplish a broader goal.

- Starting system
- Charging system
- Lighting system
- Driver information system
- Washer/wiper and horn systems
- Motorized accessories systems
- Ignition systems

  NOTE: The ignition system will be covered in the Engine Performance curriculum.

OBJECTIVE 4

Describe common electrical tools and test equipment.

- **Ammeter** — Measures the amount of current in a circuit in amperes. Conventional ammeters are connected in series with the circuit by actually opening the circuit and allowing current to pass through the ammeter. Inductive or tong-type ammeters are slipped over the outside of the wire insulation and use the magnetic field around the wire to determine amperes.

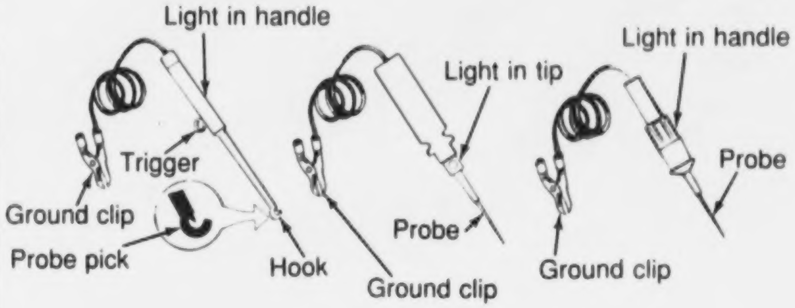
- **Continuity Test Light** — Used for checking to see that voltage is present in a circuit. A test light (sometimes called test lamp or circuit tester) has two attached leads. One lead is grounded and the other is brought into contact with various points along the circuit. When the second lead touches parts of the circuit receiving power, the light goes on.

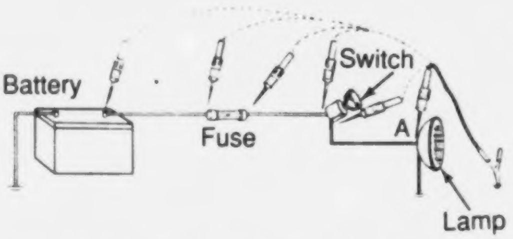
  NOTE: A self-powered test lamp contains a battery, light, and two leads. To use this test light, the battery must first be disconnected, or the circuit's fuse removed. Each of the leads are then brought in contact with points on the circuit. If the light goes on, the current from the test lamp's battery successfully traveled the portion of the circuit between the two wires.

◆ WARNING ◆

A 12-volt self-powered test light may damage solid state components, and should not be used on circuits containing them.

FIGURE 2


Light in handle
Light in tip
Light in handle
Trigger
Probe
Ground clip
Probe
Probe pick
Hook
Ground clip
Ground clip

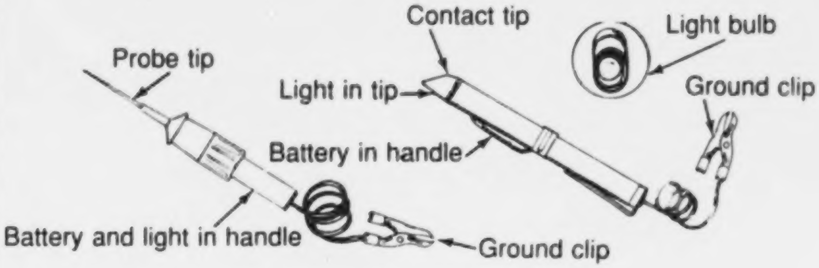

Switch
Battery
Fuse
A
Lamp

Checking for opens with a 12-volt test light

Used with permission of Ford Motor Company.

FIGURE 3

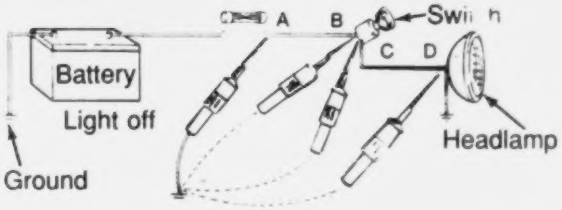
(a) Types of self-powered test lights


Contact tip
Light bulb
Probe tip
Light in tip
Ground clip
Battery in handle
Battery and light in handle
Ground clip

Used with permission of Ford Motor Company.

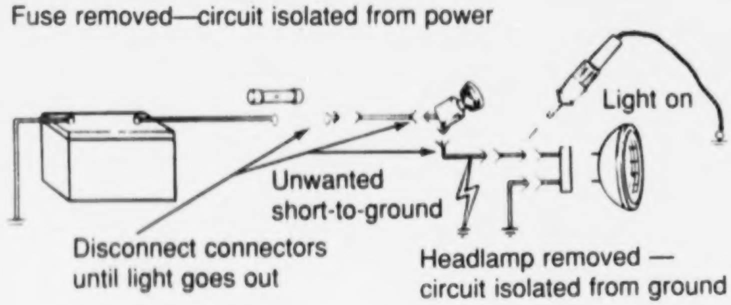
**(b) Checking for open circuits
with a self-powered test light**

Fuse removed—circuit isolated from power


A
B
Switch
C
D
Battery
Light off
Headlamp
Ground

Open isolated by probing different sections of circuit

(c) Checking for short circuits with a self-powered test light


Fuse removed—circuit isolated from power
Light on
Unwanted short-to-ground
Disconnect connectors until light goes out
Headlamp removed — circuit isolated from ground

Used with permission of Ford Motor Company.

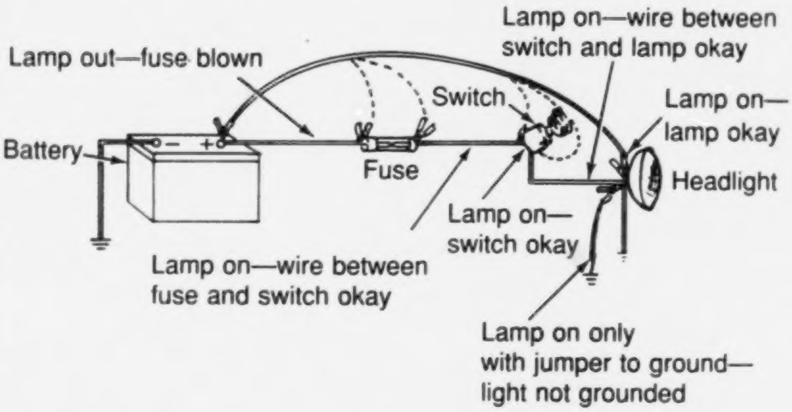
- **Hydrometer** — A float device for determining the charge of a battery by measuring the specific gravity of the battery electrolyte.

- **Jumper wire** — A test lead used to bypass a portion of a circuit. A jumper wire creates a temporary parallel circuit. If a short or ground has occurred in the "jumped" portion, the circuit will travel the jumper wire and complete the circuit.

◆ WARNING ◆

Never connect a jumper wire across loads. This will cause a direct battery short, and may result in injury or fire.

FIGURE 4



Lamp on—wire between switch and lamp okay
Lamp out—fuse blown
Switch
Lamp on—lamp okay
Battery
− +
Fuse
Headlight
Lamp on—switch okay
Lamp on—wire between fuse and switch okay
Lamp on only with jumper to ground—light not grounded

Used with permission of Ford Motor Company.

NOTE: Before using any instrument, check meter specifications and instructions. Follow manual directions.

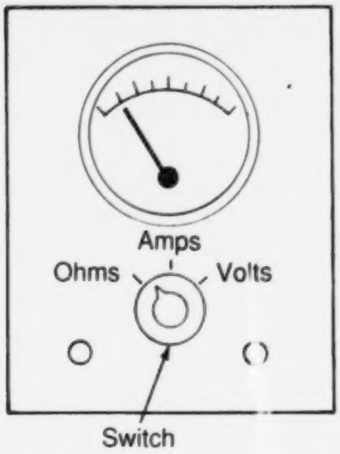
- **Multimeter** — Used for measuring voltage, current, and resistance, a multimeter is a combined voltmeter, ammeter, and ohmmeter and is the most used basic circuit analysis and testing tool in electronics. There are two types of multimeters: digital and analog.

  NOTE: Digital meters are preferred today because their more precise readings are needed when testing electronic circuits.

Before measurements can be taken with a multimeter, the function (ammeter, ohmmeter, or multimeter) must be chosen and the range set. Some multimeters now have auto-ranging.

NOTE: Meters should be checked regularly and calibrated accordingly.

FIGURE 5



CAUTION

Ohmmeters should not be connected across a live circuit. The meter may be shorted.

- **Ohmmeter** — Measures the amount of resistance (ohms) in a circuit. An ohmmeter is connected in parallel and can only be used when the circuit is not receiving power. When testing a circuit for continuity, an ohmmeter can be used instead of a voltmeter or test light. If continuity is good, resistance is low.

  NOTE: Do not use an ohmmeter if solid state components are in the circuit. The ohmmeter may damage them.

- **Voltmeter** — Measures the amount of electrical pressure (voltage) present in a circuit. A voltmeter is connected in parallel to a circuit and across loads or sources. The circuit is powered when the measurement is taken. The black lead (negative) is connected to ground and the red (positive) to the measuring point. Voltage drop of more than one volt indicates a fault in the circuit.

OBJECTIVE 5 **Distinguish among types of electrical faults.** (Assignment Sheets 1-4 and Job Sheets 1-2)

- **Ground** — A ground occurs when a conductor comes in contact with a ground—**copper touching iron**. It can be intentional, as found at the "end" of a circuit, or may be unintentional, as found when insulation fails, allowing the conductor to come in contact with the frame. A ground completes the circuit. Anything in the circuit before the ground will receive normal power, but anything after the ground will receive no power. If one path in a parallel circuit is grounded, the other path(s) will continue to receive normal power. A ground in a series circuit will prevent any part of the circuit from receiving power.

TROUBLESHOOTING A GROUND

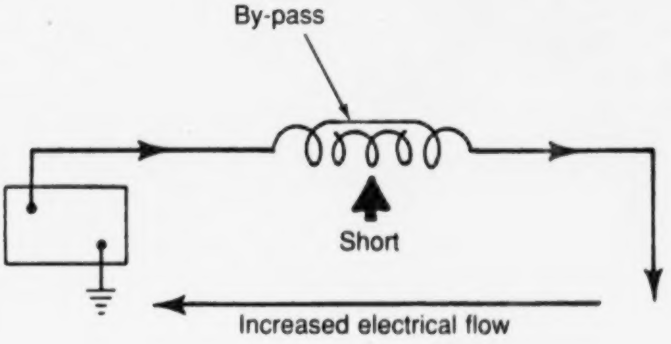
A ground (sometimes called a short to ground) is a dangerous fault. When a ground occurs, a new circuit path is created using a ground such as the chassis. This new path has very low resistance and a large current flow results. Circuit breakers or fuses will open, but if the ground occurs in such a way that no circuit protection device remains in the circuit, burnt wires or fire may result.

One way to locate a ground is to remove the circuit's fuse and connect a test lamp or voltmeter across the fuse connection. Wiggle the harness near the fuse block. If the test light goes on or the voltmeter registers, a ground is located near that point. If not, continue to wiggle the circuit at convenient points (about every six inches). The same process can be performed with a self-powered test light or an ohmmeter by first removing the fuse and disconnecting the battery and load. Connect one lead to the load side of the fuse terminal and the other to a good ground. Proceed as described above.

Another way to find the ground is by using a compass. First replace the fuse with a circuit breaker. This allows current to flow through the circuit without danger (be sure the circuit breaker does not allow more current than the proper fuse would). Hold the compass next to the leads. If current is passing through the circuit, the compass needle will deflect. It will stop deflecting where the ground has occurred.

- **Short** — A short occurs when the insulation on a conductor fails, allowing the conductor to come in contact with another conductor—**copper touching copper**. Shorts are not intentional and may result in overheated wire and fire. Nothing in a shorted series circuit will receive power. Electricity will seek the shortest path available.

TROUBLESHOOTING A SHORT



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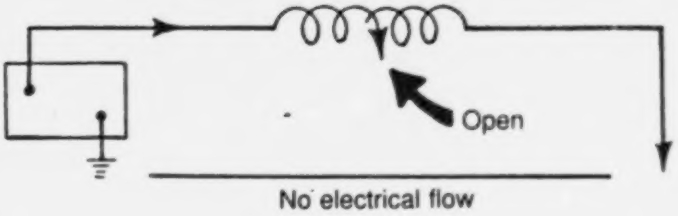
A short can be difficult to diagnose. While a ground or open circuit will prevent current from reaching certain circuits, a short may actually create new circuits. Shorts usually occur when insulation breaks, exposing the conductor, but can also be caused by a damaged wiring harness. Visually checking for these common causes is the first step.

One way to isolate a short is to check voltage along the circuits with an ammeter. Increased electrical current may indicate a short.

- **Open circuit** — An open circuit occurs when switches are open or some other break occurs in the circuit, preventing current from passing through the circuit. An open circuit can be intentional or unintentional. Blown fuses, fusible links, or open circuit breakers result in open circuits, as do loose connections and broken wires. When a series circuit is open, no part of the circuit will receive power. In a parallel series, the path containing the open circuit will receive no power, but all other paths will.

TROUBLESHOOTING AN OPEN CIRCUIT



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An open circuit means no current flows through the affected lead. In a series circuit, the entire circuit is dead. In a parallel circuit, only the lead containing the open is dead; all other leads continue to receive current.

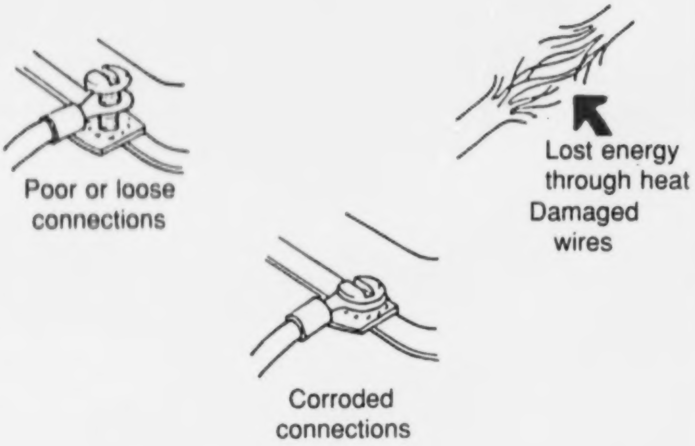
The most common way to trace an open circuit is to use a jumper wire. Connect the jumper to the load and to a good ground. If the load operates, the circuit is not well grounded. If it does not, then connect one end of the jumper to the load and other to the source. If the load operates, an open is occurring in the circuit. By moving the end of the jumper back from the load toward the battery, the site of the open can be determined.

Another method to isolate an open circuit is to use a self-powered test light. First disconnect the circuit from its voltage source by removing a fuse or disconnecting the battery. To use a self-powered test light, simply attach the ground clip to a good ground and touch the probe to the circuit. If the light is on, the open is between the light and the source. If the light is out, the open is between the light and the ground. Move the light from point to point to isolate the open.

An ohmmeter or voltmeter can be used to diagnose an open circuit. If the voltmeter is used, connect the black lead to ground and the red lead to the circuit. If voltage registers, no open has occurred between that point and the source. Remember that the circuit must be receiving power when the measurement is taken. By moving the red lead along the circuit, the site of the open can be discovered. An ohmmeter can be used in a similar manner. If resistance is high, continuity is poor. Remember to disconnect the source or remove a fuse before using an ohmmeter.

- **High resistance** — Loose or badly corroded connections increase the resistance in a circuit. These may result in reduced current, or may, in extreme cases, appear to be an open circuit. All loads in a circuit are affected by high resistance. High resistance may also be caused by using improper wire gauge, though this is not likely.

TROUBLESHOOTING HIGH-RESISTANCE PROBLEMS


Poor or loose connections
Lost energy through heat
Damaged wires
Corroded connections

Used with permission of Instructional Materials Lab, University of Missouri, Columbia, MO.

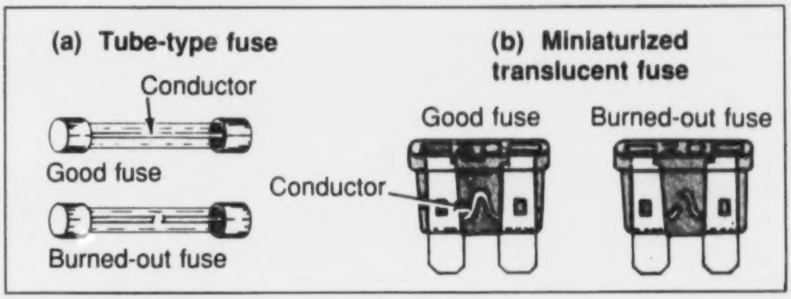
High-resistance problems are sometimes the most difficult to trace. Since these commonly involve problems with grounding, first follow the steps described for troubleshooting grounds. If the problem persists, follow the directions in the appropriate service manual.

OBJECTIVE 6

Label circuit protection devices. (Job Sheet 3)

- **Fuse** — Transparent tube or miniaturized translucent device containing a soft-metal conductor; designed so that the soft-metal conductor melts (burns out) and permanently opens the circuit when excessive current flows through it.

FIGURE 6


(a) Tube-type fuse
Conductor
Good fuse
Burned-out fuse
(b) Miniaturized translucent fuse
Good fuse
Burned-out fuse
Conductor

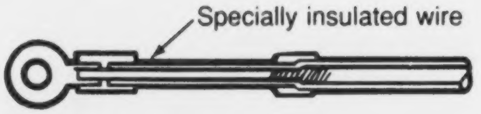
CURRENT RATING (AMPERES)	COLOR
3	VELVET
5	TAN
7.5	BROWN
10	RED
15	BLUE
20	YELLOW
25	WHITE
30	GREEN

Used with permission of General Motors Corporation.

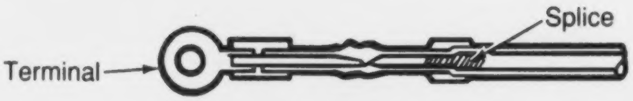
- **Fusible link** — Specially insulated wire connected in the circuit; designed so that the insulation smokes and then the wire melts, permanently opening the circuit when excessive current flows through it.

  NOTE: Links are usually 4 gauge sizes smaller than protected wire.

FIGURE 7



(a) Good fusible link



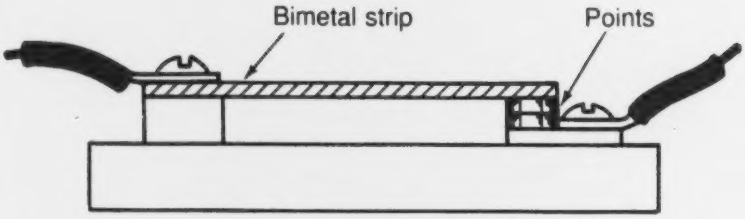
(b) Burned-out fusible link

FUSES AND FUSIBLE LINKS

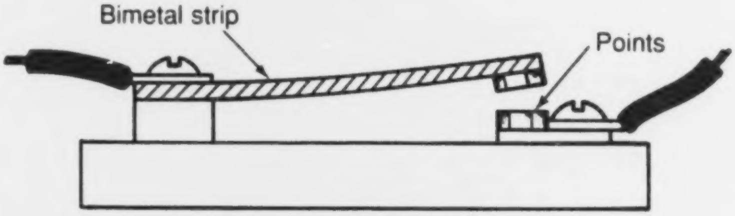
Fuses and fusible links are very similar. The major difference between the two is simple usage. Fuses are usually grouped in a panel located under the dashboard or in the glovebox. Fuses are easily found and changed. Fusible links are used under the hood, commonly near the motor, and may be more difficult to change. The amount of current they bear and the way they are used are interchangeable.

- **Circuit breaker** — Device containing a bimetal strip and a set of points; designed so that when excessive current flows through it, a bimetal strip bends away from contact points and temporarily opens the circuit until the strip cools and again touches contact points.

FIGURE 8


Bimetal strip
Points

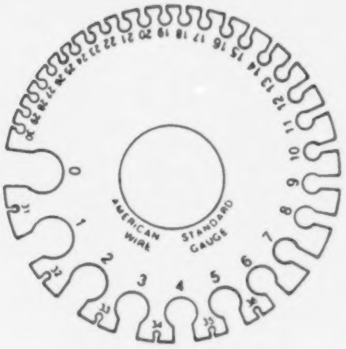
(a) Circuit breaker carries normal current; bimetal strip contacts points. Circuit is closed.


Bimetal strip
Points

(b) Circuit breaker carries excessive current; bimetal strip bends away from points. Circuit is open.

NOTE: Circuit breakers do not burn out, like fuses or fusible links, and because of this, are used for other purposes.

Standard Copper Wire Gauge Sizes



AMERICAN STANDARD WIRE GAUGE

GAUGE NO.	DIAMETER, MILS	CIRCULAR-MIL AREA	GAUGE NO.	DIAMETER, MILS	CIRCULAR-MIL AREA
1	289.3	83,690	21	28.46	810.1
2	257.6	66,370	22	25.35	642.4
3	229.4	52,640	23	22.57	509.5
4	204.3	41,740	24	20.10	404.0
5	181.9	33,100	25	17.90	320.4
6	162.0	26,250	26	15.94	254.1
7	144.3	20,820	27	14.20	201.5
8	128.5	16,510	28	12.64	159.8
9	114.4	13,090	29	11.26	126.7
10	101.9	10,380	30	10.03	100.5
11	90.74	8,234	31	8.928	79.70
12	80.81	6,530	32	7.950	63.21
13	71.96	5,178	33	7.080	50.13
14	64.08	4,107	34	6.305	39.75
15	57.07	3,257	35	5.615	31.52
16	50.82	2,583	36	5.000	25.00
17	45.26	2,048	37	4.453	19.83
18	40.30	1,624	38	3.965	15.72
19	35.89	1,288	39	3.531	12.47
20	31.96	1,022	40	3.145	9.88

*20 to 25 C or 68 to 77 F is considered average room temperature

The wire used in most imported cars and some newer domestic cars is measured in metric units. In the metric system, wire size is expressed in square millimeters (mm^2). A conversion chart, see Table 2, shows the equivalent wire sizes for the AWG and metric systems.

Table 2: Metric conversion chart

AWG wire size (gauge)	Metric wire size (mm^2)
20	0.5
18	0.8
16	1.0
14	2.0
12	3.0
10	5.0
8	8.0
6	13.0
4	19.0

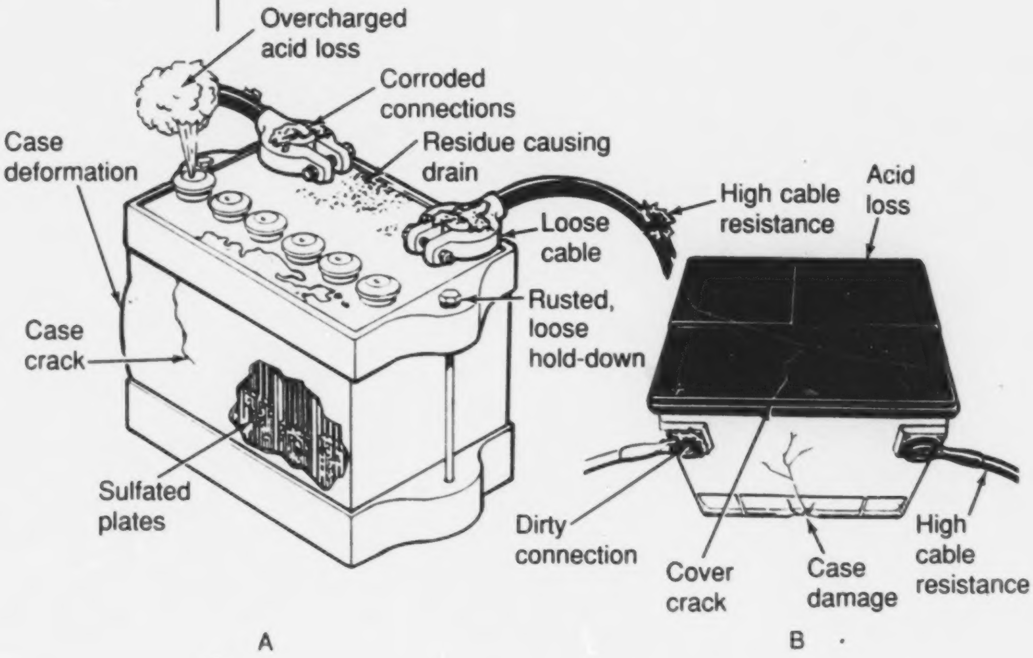
DIAGNOSING THE CAUSE OF BATTERY DRAIN

Check for loose or corroded battery connections

Before beginning any repair, set the parking brake. Put the vehicle in park if it has an automatic transmission; in neutral if it has a manual transmission. Remove the key and store it according to procedures. Open the hood and check the battery visually. The illustration below shows the major points to be checked. If you need to remove the battery, note the location of the positive terminal. Disconnect the ground terminal first. Do not hammer on the battery posts. Check the battery hold-downs and tray for corrosion. If any corrosion is noted on the cables, hold-downs or elsewhere, clean it with a solution of ¼ pound baking soda to 1 quart of water. Replace cables or clamps as needed. If the casing is cracked or the battery is otherwise defective, replace it.

CAUTION

Consult the service manual before disconnecting any battery. In some cases, improper removal will result in the loss of CPU memory.


Overcharged acid loss
Corroded connections
Residue causing drain
Case deformation
Loose cable
Rusted, loose hold-down
Case crack
Sulfated plates
High cable resistance
Acid loss
Dirty connection
Cover crack
Case damage
High cable resistance
A
B

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Check the belt drive

Excessive belt wear or improper adjustment may cause poor battery recharge. Check the belt tension specified in the manufacturer's service manual tune-up section. **Make sure the belt is riding on the sides of the pulley rather than the bottom.** Check its condition. If it is worn or glazed, it should be replaced.

Check the battery

Begin by checking the specific gravity of the battery with a hydrometer. Adjust the specific gravity according to the temperature of the electrolyte (add 0.004 gravity points to the hydrometer reading for each 10 degrees above 80; subtract 0.004 gravity points for each 10 degrees below 80).

If the specific gravity is between 1.215 and 1.270 (adjusted), the battery is currently charged, and should be load tested. If the specific gravity is below 1.215, it should be recharged, then load tested. If more than 0.050 variation exists between cells, the battery should be replaced.

BATTERY TESTING CHART

TEST RESULTS	CONDITION	CORRECTIVE PROCEDURE
GRAVITY TEST GRAVITY BETWEEN 1.215-1.270	CHARGED	MAKE HIGH RATE DISCHARGE TEST
GRAVITY BELOW 1.215	DISCHARGED	RECHARGE. MAKE HIGH RATE DISCHARGE TEST
MORE THAN 50 GRAVITY POINTS (0.050) VARIATION BETWEEN CELLS	(a) SHORTED CELL (b) ACID LOST (c) OLD BATTERY	REPLACE
LIGHT LOAD TEST MORE THAN 0.050 VOLTS VARIATION BETWEEN CELLS	(a) SHORTED CELL (b) SULFATED CELL (c) OLD BATTERY	REPLACE
HIGH RATE DISCHARGE TEST* MINIMUM TERMINAL VOLTAGE 4.5 VOLTS FOR 6-VOLT BATTERY 9.0 VOLTS FOR 12-VOLT BATTERY	(a) DISCHARGED (b) OLD BATTERY	RECHARGE REPLACE

*Ampere load should equal 2 × Amp-Hr. rating for 6-volt Batteries and 3 × Amp-Hr. rating for 12-volt Batteries.

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Load testing a battery will diagnose internal battery faults. Follow the specifications listed in the manufacturer's service manual for the appropriate load testing procedures. The terminal voltage reading should be above 9.6 volts for a 12-volt battery. If these voltage readings are not maintained, the battery should be replaced.

Check the alternator

Assemble tools: manufacturer's service manual, ammeter, voltmeter, ohmmeter, 12-volt test lamp and a carbon pile resistor.

Before testing a component like an alternator, locate the component specifications in the manufacturer's technical manual. Settings and procedures will vary and must be followed for the automobile to perform adequately. Generally, the steps are:

1. Check that all components are models specified for the machine.

2. Check all connections, leads, etc. visually.

3. Make a complete circuit check according to recommended testing procedures found in the manufacturer's service manual. This may include electronic diagnosis, which will be covered in a later unit.

ASSIGNMENT SHEET 1

ELECTRICAL SYSTEM REPAIR REQUIREMENTS I

NAME ______________________________ SCORE ________

OBJECTIVE 7 **Read and use a wiring diagram.**

INTRODUCTION No electrical/electronic work should ever be started without first locating a service manual and wiring diagram. Wiring diagrams can be very useful, but you may need some practice using and reading them.

DIRECTIONS

1. Find a service manual for your car.
2. Locate the charging system diagram and wiring diagram key.
3. Using a copy of the wiring diagram, trace the following circuitry and label all connectors, loads, and splices:
    - From battery to ignition switch
    - From battery to starter
    - From alternator to battery

Manual used ______________________________

____

Page number ______________________________

ASSIGNMENT SHEET 2

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

NAME ______________________________ SCORE ________

OBJECTIVE 8 **Determine wire gauges.**

INTRODUCTION

Remember that resistance is increased as the area of conductor is decreased. Length and area of the wire determines the resistance, but area is the most important factor. Notice that area, not diameter, is the factor determining gauge.

To determine the gauge of the wire, first count the strands in the wire. Use a wire gauge such as that shown in Supplement 1 to determine the diameter of one strand. Find the gauge number next to the correct hole. Find that same gauge number in the left hand column of the chart. Find the diameter of the strand in circular mils by moving to the figure in the second column opposite the gauge number. Multiply that diameter by the number of strands. This figure is the area in circular mils.

Using the second chart again, find the circular mil area in the right hand column. The gauge is in the left-hand column opposite the circular mil area.

The goal is to use the smallest gauge possible without compromising safety. If the circular mil area determined falls between two numbers on the chart, choose the larger gauge.

REMEMBER: The thickness of a wire with insulation has nothing to do with its gauge.

DIRECTIONS

Determine the gauge for the following wires.

1. A piece of 15-strand wire if each strand is gauge #32.

   Diameter per strand ____________
   Multiplied by number of strands equals ____________
   Corresponding gauge ____________

2. A piece of single strand wire approximately 200 mils in diameter. ____________

3. A piece of 3-strand wire if each strand is gauge #13.
   ____

ASSIGNMENT SHEET 3

ELECTRICAL SYSTEM REPAIR REQUIREMENTS I

Name ______________________________ Score __________

OBJECTIVE 9 **Interpret wiring diagrams.**

INTRODUCTION

Few tools are as useful as a wiring diagram. Using them, however, takes some practice and a "plan of attack." First, refer to the front of the repair manual for information about wiring identification and symbols used. You will also find a listing of all the diagrams in the manual. You may be able to find a diagram showing only the circuitry you are interested in rather than all the wiring in that part of the car. When you turn to the diagram you plan to trace, recall from the core curriculum that it is usually best to travel "just as electricity flows—from the high-voltage side to the low-voltage side." To do this, find the battery and work outward. If the diagram continues for several pages, it is better to work backwards from the part toward the battery. If the line you are following leads to a dead end, locate the code next to the end. You will find this same code elsewhere on the diagram and can continue from that point.

DIRECTIONS

Study the following Ford wiring diagram. Write the correct answers in the blanks.

1. If this automobile has a manual transmission, what component is found in circuit 32 between M and N? (Last page)

   ____

2. What color wire leads from the starter motor to the starter relay?

   ____

3. What size is fusible link D?

   ____

4. What page in the service manual would one go to if tracing to the fuse panel?

   ____

5. Circuit C208B is used to activate what device?

____

6. What circuits lead to the electronic engine control?

____

7. How many multiple position switches are found in this diagram? (Refer to key)

____

8. Why is the outline of the ignition switch in a dotted line?

____

____

____

ASSIGNMENT SHEET 3 - ESS
1-53

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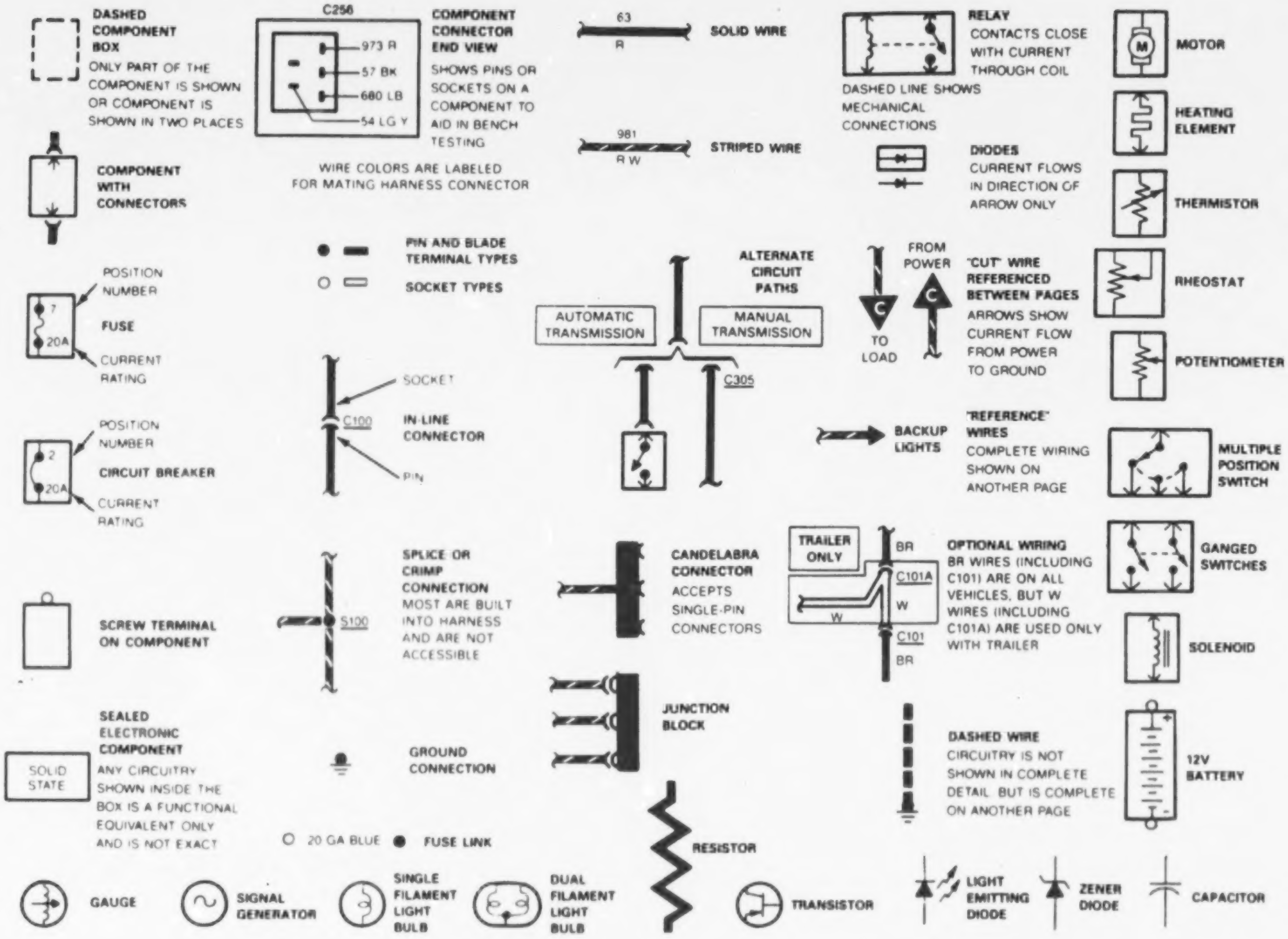

DASHED COMPONENT BOX ONLY PART OF THE COMPONENT IS SHOWN OR COMPONENT IS SHOWN IN TWO PLACES

COMPONENT WITH CONNECTORS

POSITION NUMBER **FUSE** CURRENT RATING

POSITION NUMBER **CIRCUIT BREAKER** CURRENT RATING

SCREW TERMINAL ON COMPONENT

SEALED ELECTRONIC COMPONENT ANY CIRCUITRY SHOWN INSIDE THE BOX IS A FUNCTIONAL EQUIVALENT ONLY AND IS NOT EXACT

COMPONENT CONNECTOR END VIEW SHOWS PINS OR SOCKETS ON A COMPONENT TO AID IN BENCH TESTING

WIRE COLORS ARE LABELED FOR MATING HARNESS CONNECTOR

PIN AND BLADE TERMINAL TYPES

SOCKET TYPES

IN-LINE CONNECTOR

SPLICE OR CRIMP CONNECTION MOST ARE BUILT INTO HARNESS AND ARE NOT ACCESSIBLE

GROUND CONNECTION

○ 20 GA BLUE ● **FUSE LINK**

SOLID WIRE

STRIPED WIRE

ALTERNATE CIRCUIT PATHS

CANDELABRA CONNECTOR ACCEPTS SINGLE-PIN CONNECTORS

JUNCTION BLOCK

RESISTOR

TRANSISTOR

RELAY CONTACTS CLOSE WITH CURRENT THROUGH COIL

DASHED LINE SHOWS MECHANICAL CONNECTIONS

DIODES CURRENT FLOWS IN DIRECTION OF ARROW ONLY

"CUT" WIRE REFERENCED BETWEEN PAGES ARROWS SHOW CURRENT FLOW FROM POWER TO GROUND

BACKUP LIGHTS

"REFERENCE" WIRES COMPLETE WIRING SHOWN ON ANOTHER PAGE

OPTIONAL WIRING BR WIRES (INCLUDING C101) ARE ON ALL VEHICLES, BUT W WIRES (INCLUDING C101A) ARE USED ONLY WITH TRAILER

DASHED WIRE CIRCUITRY IS NOT SHOWN IN COMPLETE DETAIL BUT IS COMPLETE ON ANOTHER PAGE

LIGHT EMITTING DIODE

ZENER DIODE

CAPACITOR

MOTOR

HEATING ELEMENT

THERMISTOR

RHEOSTAT

POTENTIOMETER

MULTIPLE POSITION SWITCH

GANGED SWITCHES

SOLENOID

12V BATTERY

GAUGE

SIGNAL GENERATOR

SINGLE FILAMENT LIGHT BULB

DUAL FILAMENT LIGHT BULB

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ASSIGNMENT SHEET 3 - ESS
I - 55

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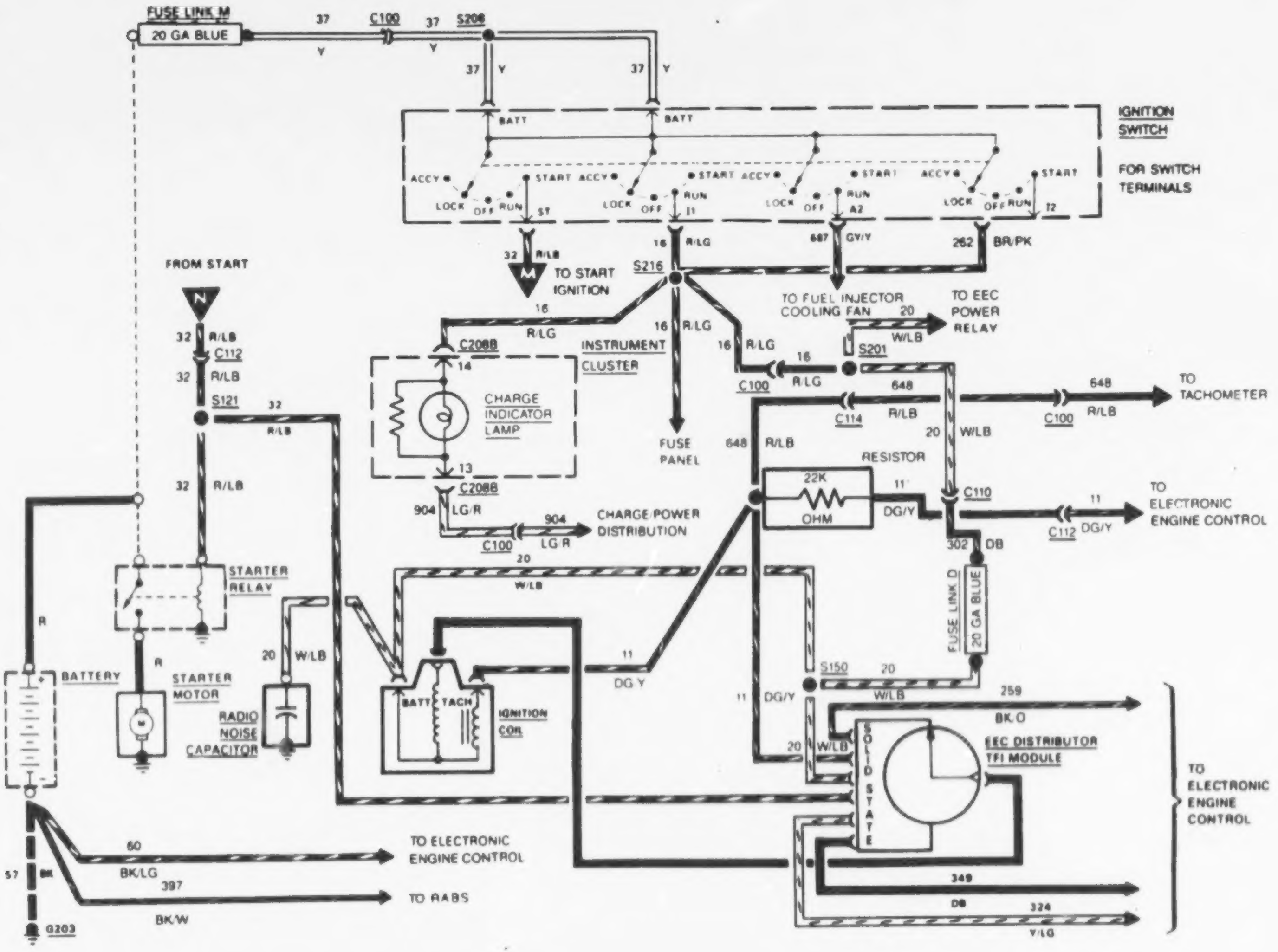
FUSE LINK M
20 GA BLUE
37
Y
C100
S208
BATT
IGNITION SWITCH
FOR SWITCH TERMINALS
ACCY
START
LOCK
OFF
RUN
ST
I1
A2
I2
32 R/LB
TO START IGNITION
16 R/LG
S216
687 GY/Y
262 BR/PK
FROM START
N
M
32 R/LB
C112
S121
C208B
14
13
CHARGE INDICATOR LAMP
INSTRUMENT CLUSTER
FUSE PANEL
TO FUEL INJECTOR COOLING FAN
TO EEC POWER RELAY
20 W/LB
S201
C100
16 R/LG
648 R/LB
C114
TO TACHOMETER
904 LG/R
CHARGE/POWER DISTRIBUTION
RESISTOR
22K OHM
11 DG/Y
C110
TO ELECTRONIC ENGINE CONTROL
302 DB
FUSE LINK D
20 GA BLUE
STARTER RELAY
R
BATTERY
STARTER MOTOR
M
20 W/LB
RADIO NOISE CAPACITOR
BATT
TACH
IGNITION COIL
11 DG/Y
S150
20 W/LB
259 BK/O
SOLID STATE
EEC DISTRIBUTOR TFI MODULE
TO ELECTRONIC ENGINE CONTROL
349 DB
324 Y/LG
60 BK/LG
TO ELECTRONIC ENGINE CONTROL
397 BK/W
TO RABS
57 BK
G203

ASSIGNMENT SHEET 3 - ESS
I - 57

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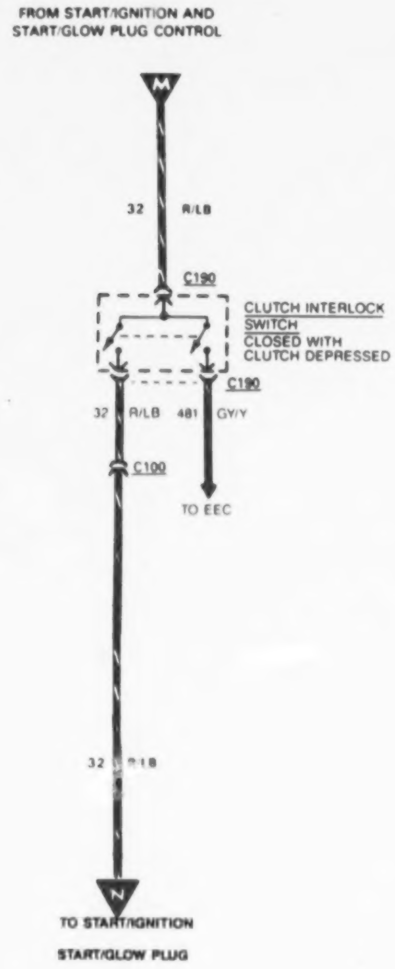
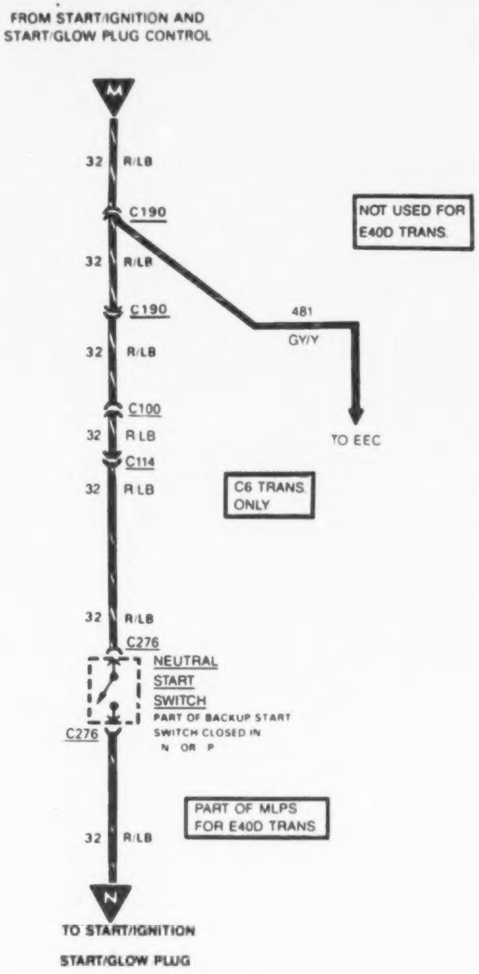
WITH MANUAL TRANSMISSION


FROM START/IGNITION AND
START/GLOW PLUG CONTROL
M
32
R/LB
C190
CLUTCH INTERLOCK SWITCH
CLOSED WITH CLUTCH DEPRESSED
C190
32
R/LB
481
GY/Y
C100
TO EEC
32
R/LB
N
TO START/IGNITION
START/GLOW PLUG

WITH AUTOMATIC TRANSMISSION


FROM START/IGNITION AND
START/GLOW PLUG CONTROL
M
32
R/LB
C190
NOT USED FOR E40D TRANS.
32
R/LB
C190
481
GY/Y
32
R/LB
C100
TO EEC
32
R LB
C114
32
R LB
C6 TRANS ONLY
32
R/LB
C276
NEUTRAL START SWITCH
PART OF BACKUP START SWITCH CLOSED IN N OR P
C276
PART OF MLPS FOR E40D TRANS.
32
R/LB
N
TO START/IGNITION
START/GLOW PLUG

ASSIGNMENT SHEET 4

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

NAME ______________________________ SCORE ________

OBJECTIVE 10

Diagnose causes of a discharged battery.

INTRODUCTION

In the core curriculum, you learned how to test and charge a battery. Remember that the battery transforms chemical energy to electrical current. The battery does not produce all the current required to operate a car. Actually, the battery has three basic jobs: to supply current needed to start the engine; to stabilize system voltage during operation; and to supply extra current when the charging system is unable to meet demand. All other current is produced by the charging system generator or alternator.

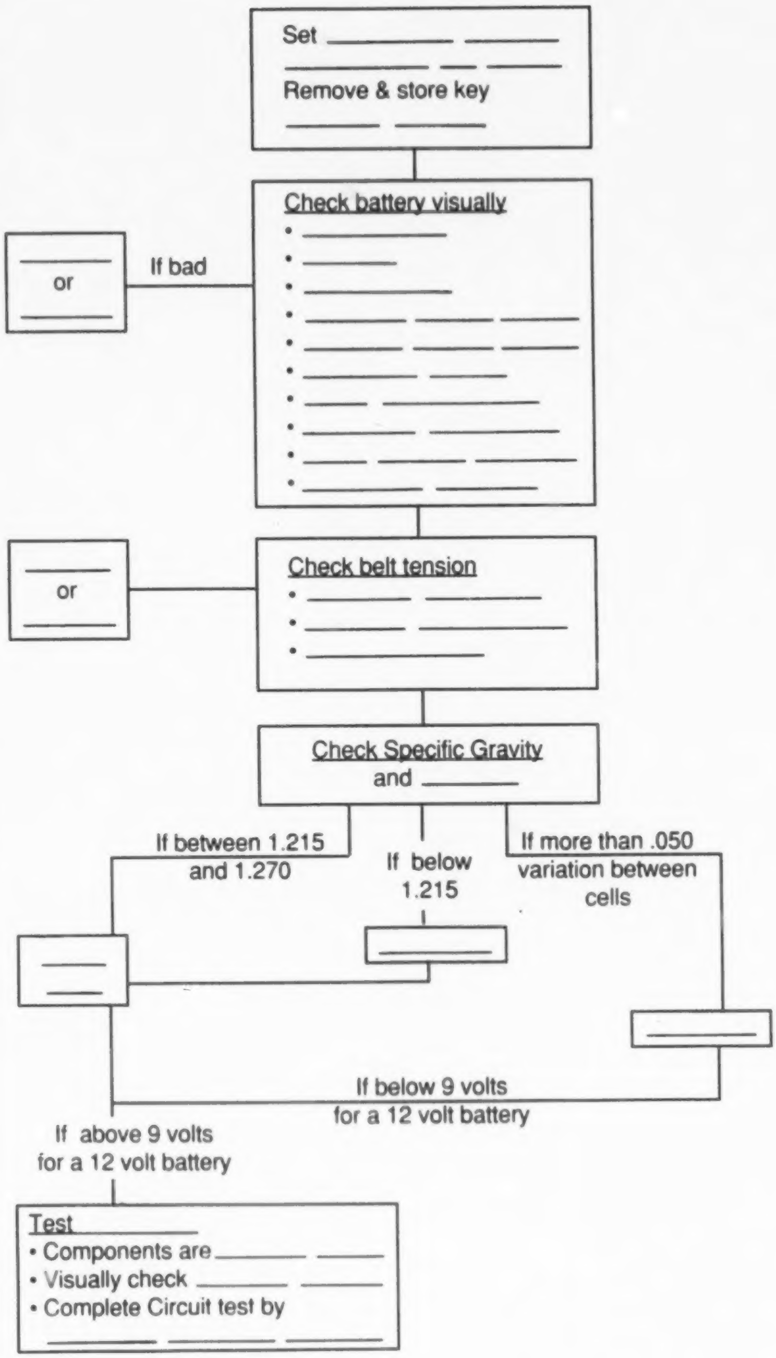
Battery drain is not the same as lack of recharge. Drain means the battery is recharging but current is being drained.. Lack of recharge means current is not available.

The most common causes of recurring battery drain include loose or corroded battery or alternator connections, defective alternator or battery, or loose or worn drive belt. Electrical accessories exceeding the capacity of the alternator or major system shorts are less likely to cause this problem.

Procedures for checking these possible causes of battery drain are found in Supplement 2.

DIRECTIONS

Complete the flow-chart on the next page. Include all test steps described above and in past instruction for load testing, checking electrolyte testing the charging system, visually checking the battery.


Set
Remove & store key
Check battery visually
or
If bad
or
Check belt tension
Check Specific Gravity
and
If between 1.215
and 1.270
If below
1.215
If more than .050
variation between
cells
If below 9 volts
for a 12 volt battery
If above 9 volts
for a 12 volt battery
Test
• Components are
• Visually check
• Complete Circuit test by

ASSIGNMENT SHEET 5

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

NAME ______________________________ SCORE _______

OBJECTIVE 11 **Determine types of circuits and the effect of faults.**

INTRODUCTION Recall from the core curriculum that there are three basic types of circuits: series, parallel, and series-parallel. In a series circuit, loads are placed in series, that is, one after another. A fault will affect all loads. In a parallel circuit, multiple leads connect the loads to the circuit. In this case, a fault will affect only the load connected to the faulted conductor. A series-parallel circuit combines the two by placing a parallel arrangement within the series. Faults in a series-parallel circuit may have varying consequences, depending upon the location of the fault.

DIRECTIONS Study the diagram on the following page. Locate a parallel circuit, a series circuit, and a series-parallel circuit, then answer the following questions.

______1. Circuit 250 is ___.

a. series
b. parallel
c. series-parallel

______2. Circuits 5 and 6 make up a ___.

a. series circuit
b. parallel circuit
c. series-parallel circuit

______3. If a ground occurred at H6-C100, would the starter solenoid selector switch continue to operate?

a. Yes
b. No

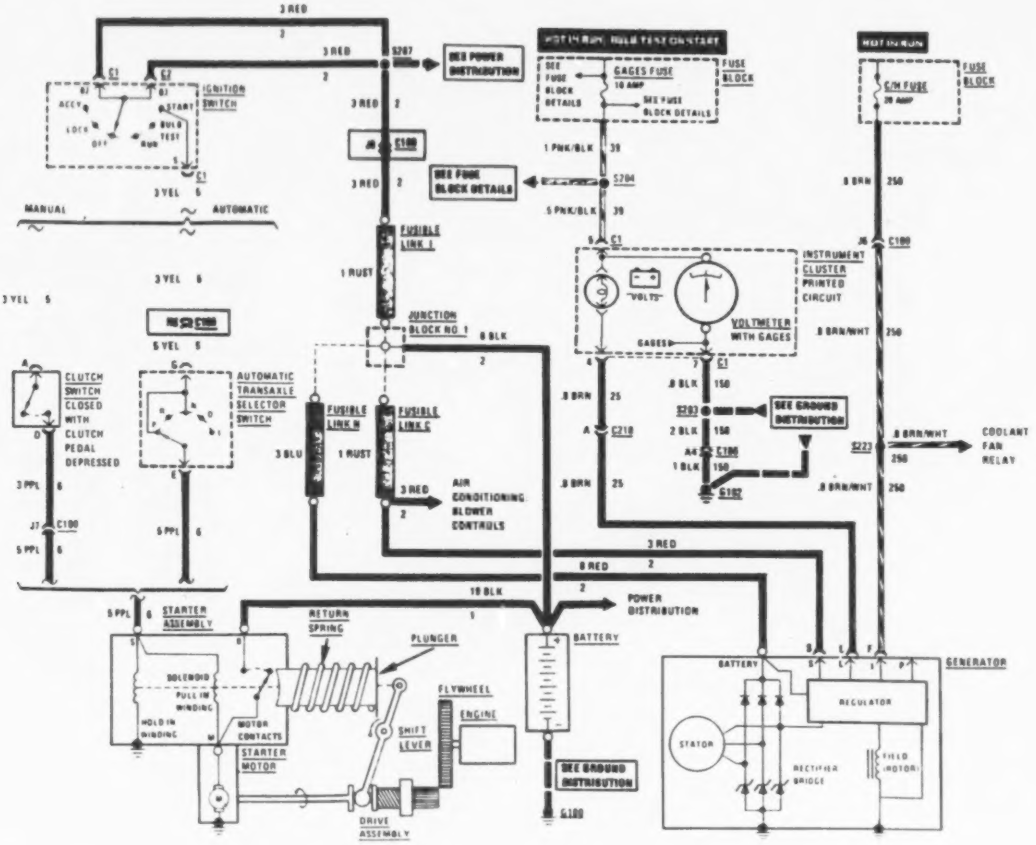
______4. If an open occurs at fusible link I, will the ignition switch work?

a. Yes
b. No

______5. If a ground occurs at J9-C100, one possible outcome would be ___.

a. Fusible Link I would open
b. Current would increase and fire may occur
c. There would be no change because J9 is a ground

STARTER AND CHARGING SYSTEM: V6 VIN W



3 RED
2
3 RED
S207
2
SEE POWER DISTRIBUTION
C1
C2
IGNITION SWITCH
ACCY
LOCK
OFF
RUN
START
BULB TEST
3 RED 2
J9 C100
SEE FUSE BLOCK DETAILS
3 RED 2
3 YEL 5
MANUAL
AUTOMATIC
FUSIBLE LINK I
1 RUST
JUNCTION BLOCK NO 1
8 BLK
2
3 YEL 6
3 YEL 5
5 YEL 5
CLUTCH SWITCH CLOSED WITH CLUTCH PEDAL DEPRESSED
AUTOMATIC TRANSAXLE SELECTOR SWITCH
FUSIBLE LINK H
FUSIBLE LINK C
3 BLU
1 RUST
3 RED
2
AIR CONDITIONING BLOWER CONTROLS
3 PPL 6
J7 C100
5 PPL 6
5 PPL 6
HOT IN RUN, BULB TEST OR START
SEE FUSE BLOCK DETAILS
GAGES FUSE 10 AMP
SEE FUSE BLOCK DETAILS
FUSE BLOCK
1 PNK/BLK 39
S204
.5 PNK/BLK 39
5 C1
INSTRUMENT CLUSTER PRINTED CIRCUIT
VOLTS
VOLTMETER WITH GAGES
GAGES
4
7 C1
.8 BRN 25
A C210
.8 BRN 25
.8 BLK 150
S203
SEE GROUND DISTRIBUTION
2 BLK 150
A4 C100
1 BLK 150
G102
HOT IN RUN
C/H FUSE 20 AMP
FUSE BLOCK
.8 BRN 250
J6 C100
.8 BRN/WHT 250
S223
.8 BRN/WHT 250
COOLANT FAN RELAY
.8 BRN/WHT 250
3 RED
2
8 RED
2
19 BLK
1
POWER DISTRIBUTION
5 PPL 6
STARTER ASSEMBLY
S
B
SOLENOID
PULL IN WINDING
HOLD IN WINDING
M
MOTOR CONTACTS
STARTER MOTOR
RETURN SPRING
PLUNGER
SHIFT LEVER
FLYWHEEL
ENGINE
DRIVE ASSEMBLY
BATTERY
SEE GROUND DISTRIBUTION
G100
GENERATOR
BATTERY
S
L
I
P
F
REGULATOR
STATOR
RECTIFIER BRIDGE
FIELD (ROTOR)

Used with permission of General Motors Corporation.

ASSIGNMENT SHEET 1

The assignment should be evaluated on the following criteria:

- Were all the circuits completely and accurately located and traced?
- Were all splices, connections, and loads labeled?

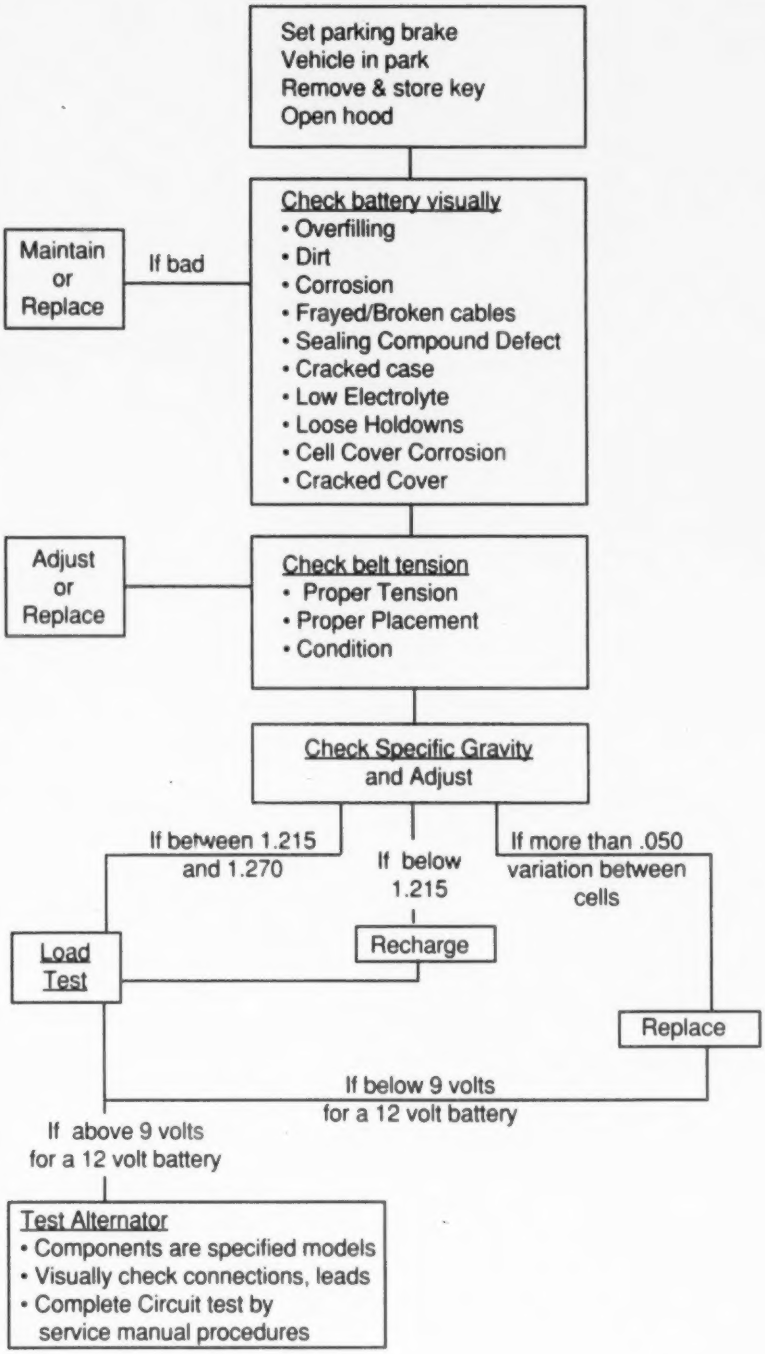
ASSIGNMENT SHEET 2

1. 7.950
   119.250
   29
2. 4
3. 26 (71.96 x 3 = 215.88)

ASSIGNMENT SHEET 3

1. Clutch interlock switch
2. Red
3. 20 GA Blue
4. 19
5. Charge indicator lamp
6. 11, 259, 349, 324, 60, 120
7. 4, 1
8. Only part of the component is shown or it is shown in another place.

   NOTE: Meanings may differ, according to the manufacturer.


Set parking brake
Vehicle in park
Remove & store key
Open hood
Check battery visually
• Overfilling
• Dirt
• Corrosion
• Frayed/Broken cables
• Sealing Compound Defect
• Cracked case
• Low Electrolyte
• Loose Holdowns
• Cell Cover Corrosion
• Cracked Cover
If bad
Maintain or Replace
Check belt tension
• Proper Tension
• Proper Placement
• Condition
Adjust or Replace
Check Specific Gravity and Adjust
If between 1.215 and 1.270
If below 1.215
If more than .050 variation between cells
Load Test
Recharge
Replace
If below 9 volts for a 12 volt battery
If above 9 volts for a 12 volt battery
Test Alternator
• Components are specified models
• Visually check connections, leads
• Complete Circuit test by service manual procedures

ASSIGNMENT
SHEET 5

1. a
2. b
3. a
4. b
5. b

JOB SHEET 1

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

OBJECTIVE 12a

Identify circuits in a vehicle.

PREREQUISITE

All Assignment Sheets

INTRODUCTION

No electrical work can be done on an automobile until the correct circuit is identified, generally with the aid of a diagram of the car's electrical/electronic systems. In this Job Sheet we will use the diagrams to identify and follow fog light circuits in a vehicle.

TOOLS AND EQUIPMENT

- Service manual
- Colored marker or highlighter
- Pencil
- Safety glasses

PROCEDURE

1. Locate the appropriate repair manual. Use the index to locate the schematic drawing that diagrams the fog light system. Make a copy of the diagram.

2. Use the symbols key in the front of the manual to help you understand the diagram. Read through the diagram until you have traced the entire circuit.

3. Mark the circuit with a colored pen or highlighter.

4. Set the parking brake on the automobile. If the car has a manual transmission, place it in neutral; if it has an automatic transmission, place it in park.

5. Turn off the car, remove the keys, and close the doors.

6. Put the keys away for safe keeping, according to shop procedure.

7. Open the hood and locate the battery.

8. From the battery, trace the circuit by following the diagram. Note any loose insulation or accidental grounds.

9. As you find each load along the circuit, mark it on the diagram.

10. When you reach the final ground, mark that on the diagram.

11. Close the hood.

12. Clean work area and return equipment and materials to proper storage.

JOB SHEET 2

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

OBJECTIVE 12b

Find shorts and grounds

INTRODUCTION

Two common faults are shorts and grounds. Grounds are much more common. As a service technician, you will need to be able to diagnose, locate, and repair both.

TOOLS AND EQUIPMENT

- Manufacturer's service manual
- Self-powered test light
- Ohmmeter or multimeter
- Jumper wire
- Safety glasses
- Fender covers

PROCEDURE

1. Locate the appropriate repair manual. Use the index to locate the schematic drawing that diagrams the affected system. Make a copy of the diagram.

2. Use the symbols key in the front of the manual to help you understand the diagram. Read through the diagram until you have traced the entire circuit.

3. Mark the circuit with a colored pen or highlighter.

4. Set the parking brake on the automobile. If the car has a manual transmission, place it in neutral; if it has an automatic transmission, place it in park.

5. Turn off the car, remove the keys, and close the doors.

6. Put the keys away for safe keeping, according to shop procedure.

7. Open the hood and locate the battery.

8. Locate the affected circuit.

9. Check for continuity (finding open circuits).

   a. Disconnect the circuit from the battery.

   b. Connect one lead of a self-powered test light or ohmmeter to each end of the circuit.

    c. If the light comes on or if resistance is low, the circuit has no open circuits.

10. Check for shorts and grounds

    a. Locate the fuse in the affected circuit.

    b. Remove power from all loads powered through the fuse. Turn off or disconnect loads, disconnect motor connectors and remove light bulbs.

    c. Power fuse by turning the ignition switch to "Run".

    d. Test for power in the circuit. Connect one test light lead to ground and the other to the "hot end" (end nearest the battery) of the blown fuse. The light should come on.

    e. Disconnect test light lead attached to ground and attach it to load side (end farthest from battery) of fuse.

        1. **If the test light is off** the short is in the disconnected equipment. Test each load by connecting it to the circuit then jumping it with a jumper wire. If the circuit runs when jumped, the load is bad.

        2. **If the test light goes on**, the wiring contains the short. One at a time, disconnect then reconnect circuit connectors. If the light goes out, the short is probably not in that area. If the light stays on, the circuit is shorted, allowing the open to be bypassed. Inspect the area between the last two disconnected circuit connectors.

11. Check for high resistance problems

    a. With circuit powered, connect a voltmeter to the suspected bad ground and frame. Any detected voltage indicates a bad ground and high resistance fault.

    or

    b. With circuit unpowered, connect a self-powered test light or ohmmeter to the suspect wire and to a good ground. If the bulb glows or low resistance is indicated, the ground is good.

NOTE: At this point, the fault should be corrected. Steps taken to correct the fault are not part of this Job Sheet.

12. Close the hood.
13. Clean work area and return all tools and materials to their proper place.

JOB SHEET 3 — ELECTRICAL SYSTEM REPAIR REQUIREMENTS I

OBJECTIVE 12c **Inspect, test, and replace circuit protecting devices**

INTRODUCTION

By knowing which circuit is receiving excessive current or how often fuses are blown, the mechanic can target testing to pinpoint the circuit fault. Of the three circuit-protecting devices, fuses, fusible links, and circuit breakers, fuses are most easily inspected, tested, and replaced. Fusible links and circuit breakers require more testing and more involved replacement procedures. When replacing any protective device, be sure the proper size replacement is used. A protective device which allows too little current will blow quickly; one allowing too much current may lead to a short or fire. As with any replacement procedure, follow safety rules.

TOOLS AND EQUIPMENT

- Service repair manual
- Replacement fuses
- Voltmeter
- Continuity test light
- Knife
- Crimping tool
- Replacement fusible links
- Wire strippers
- Connecting links
- Soldering tools and solder
- Electrical tape
- Ohmmeter
- Safety glasses
- Fender covers

PROCEDURE

Fuses

1. Set the parking brake and put the car in park (automatic transmission) or neutral (manual).

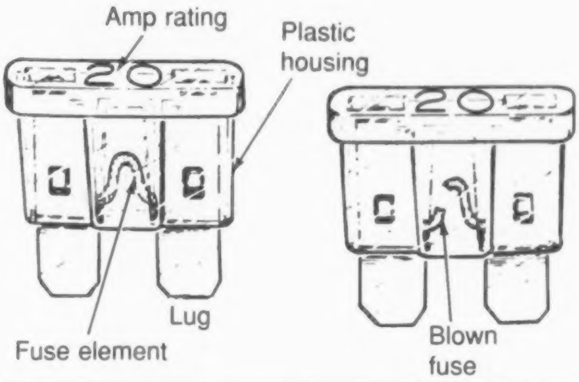
2. Use the service manual to locate fuse blocks.

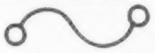
3. Lift out fuses one at a time from the fuse block.

4. As each fuse is removed, inspect it visually. A blown fuse will have a broken element and should be replaced.

5. Connect a test light to ground and to either side of the fuse. If one side shows power, replace the fuse. If both are unpowered, energize the circuit and repeat.

6. To replace a blown fuse, determine the proper size. Replacement fuses must be of the correct rating to protect the system.



Fuse	
Symbol	Letter designation
	F

Used with permission of Buick Motor Company.

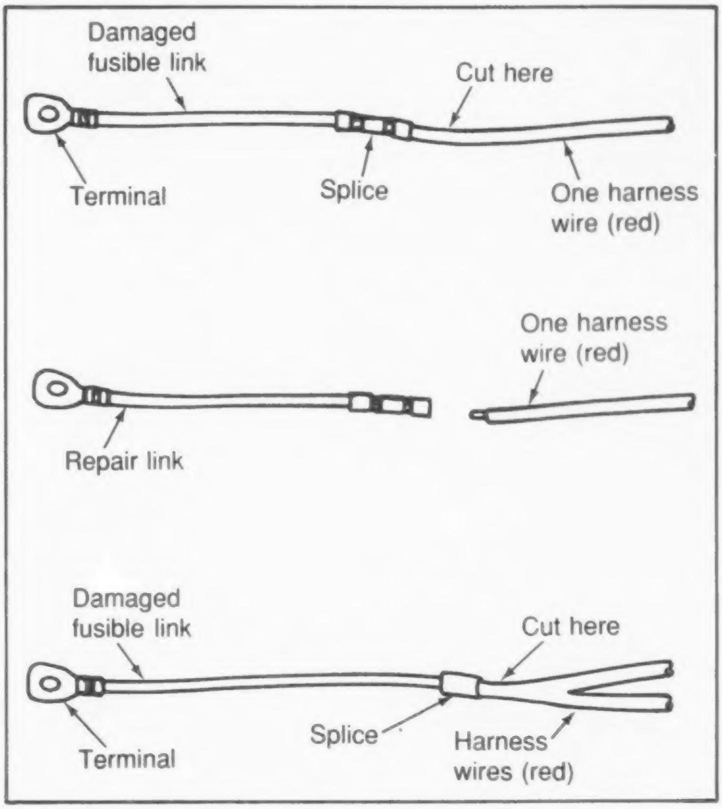
PROCEDURE

Fusible links

1. Use the service manual to locate fusible links.

2. Determine if voltage is continuing through the fusible link by connecting a voltmeter or test light to a good ground and to the lead past the fusible link. If the light comes on or the voltmeter registers current, the link is intact. If no current registers, the link has blown and should be replaced.

3. Remove the blown link by cutting it off beyond the splice. If the link feeds two harness wires, cut them both off beyond the splice and use two repair links. Make certain that each splice is at least 1½ inch from other splices, branches, or connectors.


Damaged fusible link
Cut here
Terminal
Splice
One harness wire (red)
One harness wire (red)
Repair link
Damaged fusible link
Cut here
Splice
Terminal
Harness wires (red)

Used with permission of General Motors.

4. Select the proper replacement link.

   NOTE: A fusible link is four wire-gauges smaller than the cable it protects, even though it appears much larger. The thicker insulation is a safety feature. There are two types of insulation used on fusible links: Hypalon® and Silicone/GXL (SIL/GXL). Hypalon cannot be used to replace a link made with SIL/GXL, but SIL/GXL can be used to replace either type. To determine the fusible link type, nick the insulation of the blown link. If the insulation core is the same color as the outer shell, it is Hypalon; if the core is white and the shell is another color, it is SIL/GXL.

5. Determine the length of the link. Choose the shortest usable length.

   NOTE: A fusible link should **never** be more than nine inches in length.

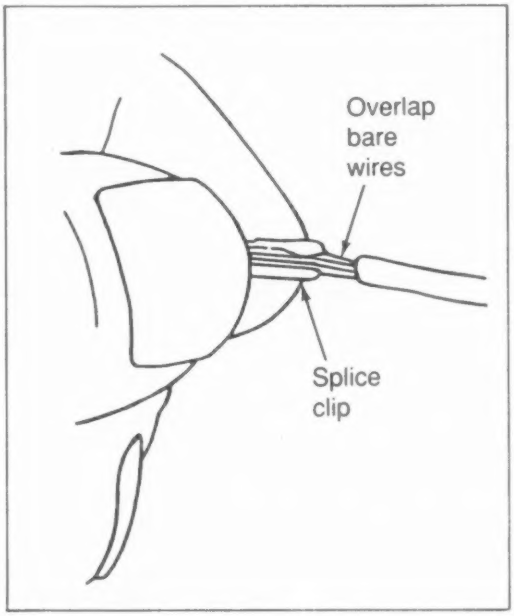
6. Use wire strippers to strip insulation from the fusible link and from the lead it will be connected to.

7. Test wiring and link for proper fit in connector and adjust stripping as necessary.

8. Inspect stripping job on lead and on link for damage to wire.

9. Select the proper connecting clip.

10. Hold the overlapped wires between thumb and forefinger (see diagram). Center the splice clip under the wires.



Used with permission of General Motors Corporation.

11. Open the crimping tool, resting one handle on a flat surface.

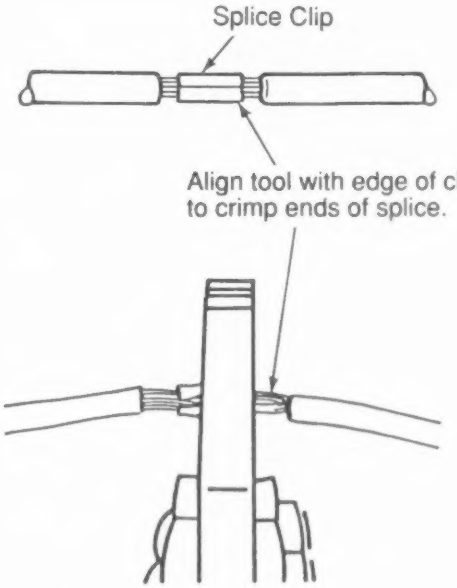
12. Place the splice clip on the proper anvil, centering the back of the clip.

13. Close the crimping tool until the splice clip is held firmly but not crimped.

14. Inspect the clip and wires again. Be sure:

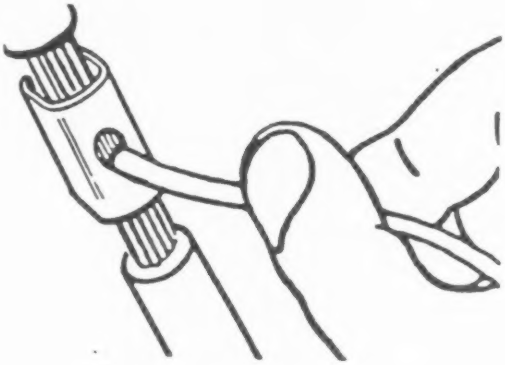
    - the wires are not damaged,
    - stripped wire extends from each end of the clip,
    - no insulation is under the clip.

15. Crimp the splice by applying a steady, firm pressure to the to the crimping tool.


Splice Clip
Align tool with edge of clip to crimp ends of splice.

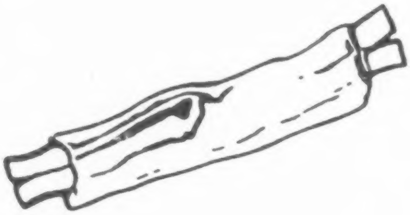
Used with permission of General Motors Corporation

16. Apply a 60/40 rosin core solder to the opening in the back of the clip



Used with permission of General Motors Corporation.

17. Tape the splice. Tape to a thickness equal the thickness of the insulation.



Used with permission of General Motors Corporation.

PROCEDURE

Circuit breakers

Unlike fuses and fusible links, circuit breakers are not replaced when they blow. Testing circuit breakers for current will help pinpoint the source of a problem. In some cases, circuit breakers must be reset.

1. Use the service manual to locate circuit breakers.
2. Connect an ohmmeter or voltmeter to the circuit breaker and ground, following instructions for use.

CAUTION

An ohmmeter can only be used when the circuit is receiving no power.

3. If the circuit breaker is blown, it will show full resistance or no voltage.
4. If the circuit breaker is blown, locate the reset opening.
5. Insert a small wire in the opening and push against the spring tension.
6. Retest with ohmmeter or voltmeter.

PRACTICAL TEST 1

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

JOB SHEET 1

Identify circuits in a vehicle.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. __

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly identified the circuit on the diagram.	_____	_____
3. Located the battery and all loads along the circuit.	_____	_____
4. Noted any faults in the circuit.	_____	_____
5. Observed safety rules throughout the procedure.	_____	_____
6. Cleaned work area and properly stored equipment and materials.	_____	_____
7. Used proper tools correctly.	_____	_____
8. Performed steps in a timely manner.	_____	_____
9. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Safety rules were followed carefully.	4	3	2	1
The complete circuit was followed.	4	3	2	1
The diagram was read and understood.	4	3	2	1
Care was given to note faults.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

JOB SHEET 2

Find shorts and grounds.

STUDENT'S NAME ______________________ DATE ________

EVALUATOR'S NAME ______________________ ATTEMPT NO. __

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly identified components, circuits, and loads.	_____	_____
3. Followed directions.	_____	_____
4. Understood the functions of the tools used.	_____	_____
5. Observed safety rules throughout the procedure.	_____	_____
6. Cleaned work area and properly stored equipment and materials.	_____	_____
7. Performed steps in a timely manner.	_____	_____
8. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
All tests were conducted in a safe manner.	4	3	2	1
Faults present were located.	4	3	2	1
Functions of the tools were well understood and applied.	4	3	2	1
An understanding of current was displayed.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

I

JOB SHEET 3

Inspect, test, and replace circuit protecting devices.

STUDENT'S NAME ______________________ DATE ________

EVALUATOR'S NAME ______________________ ATTEMPT NO. __

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Obtained proper equipment and materials.	____	____
2. Properly identified the circuit on the diagram.	____	____
3. Removed and tested fuses.	____	____
4. Observed safety rules throughout the procedure.	____	____
5. Cleaned work area and properly stored equipment and materials.	____	____
6. Properly determined replacement sizes and types.	____	____
7. Used proper tools correctly.	____	____
8. Performed steps in a timely manner.	____	____
9. Provided satisfactory responses to questions asked.	____	____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Safety rules were followed carefully.	4	3	2	1
Removed link cleanly, with 1½" margins.	4	3	2	1
Stripped and spliced lead and link cleanly with no damage to wire and no exposed wire.	4	3	2	1
Soldered cleanly and completely.	4	3	2	1
Performed continuity tests easily.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

ELECTRICAL SYSTEM REPAIR REQUIREMENTS

Name ______________________________ Score ________

OBJECTIVE 1

Match terms associated with diagnosing electrical system repair to their definitions. Write the correct letters in the blanks.

______1. A unit of measure of the amount of electrical pressure causing electrons to flow

______2. A circuit component that converts electrical energy to some other form of energy

______3. A combination of components connected to form a pathway through which electrons can flow

______4. A unit of measure of the amount of electrical current; the number of electrons flowing past a given point per second

______5. Powered by a flow of electricity through conductors, usually wire, that produces heat or heat and light

______6. A unit of measure of resistance; the amount of opposition offered to the flow of electrons by the substance through which it is passing

______7. A piece of wire carrying current

a. Ampere

b. Circuit

c. Continuity

d. Electrical

e. Lead

f. Load

g. Motor

h. Ohm

i. Path

j. Volt

k. Watt

OBJECTIVE 2

Select from a list basic electrical components. Place an "X" in the blank before all electrical components.

______1. Battery

______2. Light bulb

______3. Voltage regulator

______4. Washer pump, washer/wiper switch, and wiper motor assembly

______5. Power window switches and motors

______6. Multimeter

______7. Starter

______8. Fuses, fusible links, and circuit breakers

______9. Warning indicator sensors, switches, modules, and buzzers or chimes

_____10. Battery cables

_____11. Driver information gauges (ie, tachometer, coolant temperature gauge)

_____12. Lighting system flashers and switches

_____13. Power windows

_____14. Stereo system

_____15. Horn, lighter, radio, and clock

OBJECTIVE 3 **List basic electrical systems.**

____

____

____

____

____

____

OBJECTIVE 4

Describe common electrical tools and test equipment. Write a brief description of the tool and its function.

1. Ammeter

____

____

____

2. Continuity test light

____

____

____

3. Hydrometer

____

____

____

4. Jumper wire

____

____

____

5. Multimeter

____

____

____

6. Ohmmeter

____

____

____

7. Voltmeter

____

____

____

OBJECTIVE 5

Distinguish among types of electrical faults. Write a "G" in the blank before statements concerning grounds; "S" in the blanks before shorts; "O" in the blank before opens; and "R" in the blank before high resistance.

______1. Occurs when current cannot pass through the circuit.

______2. Everything in the system before it receives full power, everything after it receives none.

______3. Can be caused by a loose connection.

______4. Caused by fuses, fusible links, and circuit breakers.

______5. Completes a circuit.

______6. Copper touching copper.

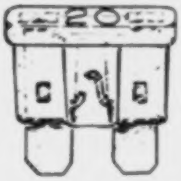
______7. Copper touching iron.

______8. Can appear as reduced current.

OBJECTIVE 6

Label circuit protection devices. Label the circuit protection device shown.

1.



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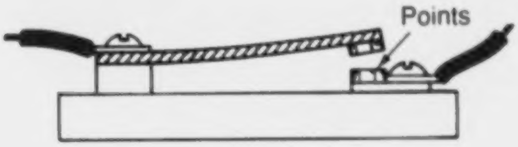

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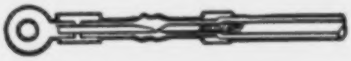

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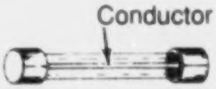
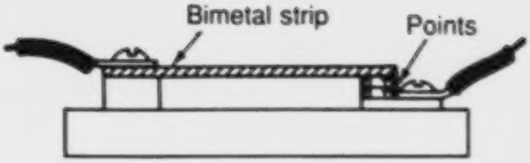


5. 

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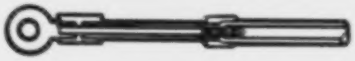
6. 

____

NOTICE The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.

OBJECTIVE 7	**Read and use wiring diagrams.**	SCORE ______
OBJECTIVE 8	**Determine wire gauges.**	SCORE ______
OBJECTIVE 9	**Interpret wiring diagrams.**	SCORE ______
OBJECTIVE 10	**Diagnose causes of battery drain.**	SCORE ______
OBJECTIVE 11	**Determine types of circuits and the effect of faults.**	SCORE ______
OBJECTIVE 12	**Demonstrate the ability to**	
	a. **Identify circuits in various vehicles.**	RATING ______
	b. **Find shorts and grounds.**	RATING ______
	c. **Inspect, test, and replace circuit protection devices.**	RATING ______

OBJECTIVE 1

1. j
2. f
3. b
4. a
5. d
6. h
7. e

OBJECTIVE 2

1, 3, 4, 5, 7, 9, 11, 12, 15

OBJECTIVE 3

(Listed in any order)

- Starting system
- Charging system
- Driver information system
- Washer/wiper and horn systems
- Lighting system
- Motorized accessories

OBJECTIVE 4

Answers may vary, but must include the following points:

1. Ammeter
    a. The ammeter measures the amount of current.
    b. There are two types of ammeters.
    c. An ammeter has two leads and a readout.

2. Continuity Test Light
    a. It tests for presence of current.
    b. A test light contains two leads and a light.

3. Hydrometer
    a. A hydrometer is made of a bulb and float.
    b. It is used to check battery electrolyte level which can be used to determine charge.

4. Jumper wire
    a. It is a piece of wire used to jump a suspected fault.
    b. It creates a parallel circuit.
    c. If the current flows with the jumper wire but not without it, the short is in the jumped portion of the circuit.

5. Multimeter
    a. A multimeter is a combined ohmmeter, ammeter, and voltmeter.
    b. There are two types of multimeter.
    c. It is made of two leads and a readout.

6. Ohmmeter
    a. An ohmmeter is made of two leads and a readout.
    b. It measures resistance.
    c. It can only be used when the circuit is not powered.
    d. It can be used to measure continuity or voltage (low resistance = high continuity

7. Voltmeter
    a. It is made of two leads and a readout.
    b. It measures electrical pressure.
    c. It can be used to check continuity.

OBJECTIVE 5

1. O
2. G
3. R
4. O
5. G
6. S
7. G
8. R

OBJECTIVE 6

1. Burned fuse
2. Open circuit breaker
3. Burned fusible link
4. Good fuse
5. Closed circuit breaker
6. Good fusible link

OBJECTIVE 7 See answers to Assignment Sheet 1.

OBJECTIVE 8 See answers to Assignment Sheet 2.

OBJECTIVE 9 See answers to Assignment Sheet 3.

OBJECTIVE 10 See answers to Assignment Sheet 4.

OBJECTIVE 11 See Practical Tests 1-3.

OBJECTIVE SHEET

ELECTRONIC SYSTEM REPAIR REQUIREMENTS *II*

INTRODUCTION

We live in the age of the computer. Computers process our bills, figure our grades, and play games with us. We find computers in our homes, schools, offices, garages, and cars. Electronic circuitry in today's automobiles monitors, corrects, and controls basic functions on most cars, and nearly all functions on others. When linked with electronic diagnostic equipment, the automobile's computer can diagnose its own faults.

UNIT OBJECTIVE

After completing this unit, the student should be familiar with terms related to diagnosing electronic system repairs, electronic components, systems, and test equipment. The student should be able to interpret wiring diagrams, solder electronic devices, splice wiring, replace connectors and PROM units. The student will also understand the effect of electronics on automotive design. The student will demonstrate these competencies by completing an assignment sheet, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with diagnosing electronic system repair requirements to correct definitions.
2. Complete statements about electronic parts and components.
3. List major electronic systems.
4. Label electronic test equipment.
5. Interpret wiring diagrams. (Assignment Sheet 1)
6. Perform basic electronic diagnosis and repair:
    a. Remove and install Metric-Pack and Weather-Pack connectors. (Job Sheet 1)
    b. Splice wiring. (Job Sheet 2)

PREPARATION

- Review unit and plan presentation.
- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.
- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.
- Review teaching suggestions and plan classroom activities.
- Determine how you will schedule time for students to demonstrate competence in the required procedures.
- Order materials to supplement unit.
- Invite an electrical specialist or electronics engineer to speak to the class.

  NOTE: Supply guest speakers with the Objective Sheet, Information Sheet and any other components you want them to cover.

DELIVERY

Objective 1 Match terms associated with electronic system repair requirements to their correct definitions.

- Have examples of the electronic items to further illustrate the difference between electrical and electronic.
- Explain valence, conductors, semi-conductors, and insulators.
- Use examples of input and output such as we smell coffee (input) and our brain says "go get a cup of coffee--you're thirsty" (output). Have students offer other illustrations.

Objective 2 Complete statements about electronic parts and components.

- Have a wide variety of examples of the parts and components listed. Have photographs or drawings available of other examples.

- Explain the relationships between the parts and components: input, ECM, output; diodes, rectifiers, and transistors; etc.

- Show video *Computerized Engine Control.*

- Show video tape *From Sand to Solid State.*

- Have information on the construction and operation of the parts and components available for students wishing to have this information, but stress that it is not necessary that they know how a diode, for example, works. It is more important that they understand how it fits into the system.

- Have students inspect a service manual or parts catalog and list all the examples they find of switches, relays, and sensors.

- Be sure students understand that the components found will vary dramatically from car to car.

Objective 3 List major electronic systems.

- Show students parts catalogs or service manuals to impress upon them the variety of systems affected by electronics.

- Discuss emission control laws and their effect upon automotive design and service.

- Review the ignition and fuel system functions, noting differences between conventional and electronic systems.

- Illustrate the need for a thorough knowledge of automotive systems by suggesting that one sensor in the ignition or fuel system is malfunctioning. If the ECM receives false information from the one sensor, what adjustments will it make? What effect will these adjustments have on the performance of the vehicle?

- Have students complete Activity Sheet 1.

Objective 4 Label examples of electronic test equipment.

- Note that most of these test items were used in Unit I.

- Note limits on test equipment i.e., digital voltmeters and unpowered test lamps.

- Explain the use of a dwell meter to familiarize them with the instrument.
- Allow students to use vacuum pumps and gauges and dwell meters.

APPLICATION

Objective 5 Interpret wiring diagrams.

- Introduce students to other reference materials such as diagnostic charts and flowcharts.
- Display schematics of circuit boards and compare them to wiring diagrams.
- Have students attempt to draw a wiring diagram.
- Have students complete Job Sheets 1 and 2.

Objective 6a Remove and install Metri-Pack and Weather-Pack connectors.

- Explain to students that electronic parts and components are not usually serviced. If testing indicates that they are faulty, they are replaced.
- Show filmstrips in the *Soldering for Electronic Repair* series.
- Show video tape *Packard Electronic Wire Repair.*
- Discuss the fragile nature of electronic parts.

Objective 6b Splice wiring.

- Compare splicing done in Unit I to Job Sheet 1.
- Have students inspect various harness and connectors.

EVALUATION

Pretest

- Pretest qualifying students.
- Determine individual requirements from pretest results.
- Counsel students individually on pretest results and study requirements.

- Modify materials in unit or create supplementary materials for individual students as required.

Practical test

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.
- Complete appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Publications

- *Automotive Electrical and Electronic Systems.* 2-volume Chek-Chart set with a manual on theory and one providing detailed service procedures. Order No. 454014, available from Chek-Chart Publications, P.O. Box 49006, Attn: Accounting Dept., San Jose, CA 95161-9006, phone 1-800-662-6277.
- *Ford Electronic Engine Controls.* Student texts with test diagnostic procedures for various systems. EEC-III, including feedback carburetor and electronic fuel injection (Order No. 0901-042); Microprocessor Control Unit for 4, 5, and 8 cylinder engines (Order No. 0901-043); and EEC I, II, and III systems (Order No. 0901-044). Available from Ford's Service Publicatons, phone 1-800-782-4356.

- *Fundamentals of Computer Command Control Course Manual* (#GM-16016-051) explains computer controlled fuel, air, ignition and spark management for carburetor systems; system diagnosis. 156 pages. It can be ordered from General Motors Training Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28365 Mound Road, Warren, MI 48029 or by calling 1-800-468-6657.

Media

- *Automotive Electronics Explained.* Five VHS programs or five filmstrips and cassettes averaging 11-19 min. Sections are "Comparing Old and New Systems," "Basic Concepts and Equipment," "Microprocessor Design and Usage," Schematics and Components," and "Troubleshooting Techniques." Order Nos: Filmstrips/cassettes: BP-493-V9; VHS cassettes BP-493X-V9, available from NIMCO, phone 1-800-962-6662.

- *Basic Electronic Tests Instruments.* This three-part set of video cassettes (#823X) includes:

    — "Introduction to Multimeters" compares analog and digital, describes use and maintenance.

    — "Resistance and Continuity Measurements" shows meter setup and use.

    — "Voltage and Current Measurements" covers meter selection and breadboarding.

- *The Automotive Computer* is a four-videotape set used in ASE certification programs and corresponds with the NATEF Task List: (#A27).

    — "Explaining the Black Box" covers evolution and the role of automotive computer systems.

    — "Input-Sensors" discusses electrical principles, compares analog and digital signals, and use of sensors.

    — "Output Actuators" covers the use and functions of solenoids and relays and explains how signals are converted.

    — "The Computer in Action" shows computer adjustments, diagnoses, and ROM, PROM, and RAM memories.

- *Soldering for Electronic Repair.* This three-program series can be purchased in a three-filmstrip/three-cassette (20 to 23 minutes each) version with a study guide (order number 865-V9) or in a three-VHS-cassette (20 to 23 minutes each) version with a study guide (order number 865X-V9). Produced for basic electronics students, techniques included in the first two programs especially will transfer to techniques required in automotive mechanics. Topics in each program are listed below.

  Program 1: "Basic Techniques" explains various types of soldering and composition and types of solder; describes and soldering tools; stresses safety in handling soldering equipment; and demonstrates how to solder a typical circuit-board connection.

  Program 2: "Soldering Terminals" describes common soldering terminals, shows steps for soldering each terminal type, and demonstrates how to solder a cable to a standard DB-25 connector, stressing safety and inspection of own work and clearly showing acceptable and unacceptable soldering techniques.

  Program 3: "Soldering Printed Circuit Boards" describes the printed circuit board and the use of the plating and solder mask; explains common electronic-component types, lead configuration, and integrated-circuit types; features component and board preparation and proper heat and solder application; stresses inspecting your own work; clearly shows acceptable and unacceptable circuit-board soldering; describes common printed-circuit-board soldering problems; and shows how to remove components and clean boards.

  Order the set from: Bergwall Productions, Inc., P.O. Box 238, Garden City, New York 11530-0238, telephone 1-800-645-3565 (all states except New York) or 1-800-645-1737.

  - *Computerized Engine Controls*, a 60-minute video tape offered by Fram as part of their "Shop Talk" series. For information about pricing and the complete package, write: Fram Division, Allied Automotive, SHOP TALK, 105 Pawtucket Avenue, East Providence, Rhode Island, 02916.

- General Motors offers a series of four video tapes on the construction, testing, repair and function of electronic components includes "Oscilloscope Operation and Measurement" (#GM-18001-2V1) for instructor review, and "Silicon Sand to Solid State" (#GM-18001-2V3), "Packard Electronic Wire Repair" (#GM-18001-2V5), and "Controlling Electrostatic Discharge" (#GM-18001-2V6) for students. To order, write General Motors Training Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28365 Mound Road, Warren, MI 48029 or by call 1-800-468-6657.

Computer Software

- *Automotive Electronics — GM Computer Command Control*, 1989. Covers Automotive Electronics, General Motors Computer Command Control (C-3) and General Motors Computer Command Control Input/Output. Three copyable disks offer these three lessons and quizzes. Order No. SW321, available from Shopware Education Systems, Department KL-3, 101 Hill Road, Aberdeen, WA 98520-7302, phone (206) 532-3392.

Other

- "General Motors Specialized Electronics Training Student Workbook Package" and "General Motors Specialized Electronics Training Lab Kit." The workbook package contains student materials for General Motor's *Specialized Electronics Training*, including binder, workbook, and "Getting Started in Electronics" handbook (#GM-18001-02W). The lab kit includes 10 weather-pack connectors with seals, 10 metri-pack connectors, 4 insulated alligator clips, and necessary wire and solder (#GM-18001-2K1).

UNIT REFERENCES

- *C/K Pickup Electrical Diagnosis and Wiring Diagrams.* General Motors Corporation, 1989.
- DeKryger, et al, *Auto Mechanics: Theory and Service.* Cincinnati: South-Western Publishing Company, n.d.
- *Electronic Ignition Diagnosis and Testing, 1985 Edition.* Sun Electric Corporation and Mitchell Information Services, Inc., 1985.

- Mackert, Howard C., *Automotive Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- *Mitchell Electrical Service and Repair Domestic Cars, 1987 Supplement.* San Diego, California: Mitchell International, Inc., 1987.
- *Mitchell Computerized Engine Controls.* San Diego, California: Mitchell International, Inc., 1988.
- *Motor Truck Engine Tune Up and Electronics Manual.* New York: The Hearst Corporation, 1984.
- Weathers, Tom, Jr. and Claud C. Hunter, *Automotive Computers and Control Systems.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1984.

PRETEST ANSWERS

ELECTRONICS SYSTEM REPAIR REQUIREMENTS II

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel the student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Questions
1	1-4
2	5-13
3	14-17
4	18-21
5	22-23
6	24-

ANSWER KEY

1. c
2. a
3. c
4. c
5. b
6. a
7. b
8. c
9. a
10. b
11. c
12. b
13. a
14. a
15. b
16. c
17. b
18. c
19. b
20. c
21. a
22. b
23. a
24. a
25. a
26. b
27. b
28. b
29. a

ELECTRONIC SYSTEM REPAIR REQUIREMENTS

NAME ______________________________ SCORE ______

______1. A unit is electronic if it ___.

- a. is run by electricity
- b. is powered by the flow of electrons through a conductor
- c. is powered by the flow of electrons through semiconductors

______2. Input is information from the ___.

- a. sensors to the ECM
- b. electronic specialist to the inboard computer
- c. ECM to the electronic specialist

______3. Output is commands from the ___.

- a. ECM to sensors
- b. electronic specialist to the ECM
- c. the ECM to control devices

______4. A semi-conductor is ___.

- a. a small piece of copper wire
- b. a plastic board with electronic circuitry etched in it
- c. an atom with four electrons in the outer shell

______5. Another name for a capacitor is ___.

- a. rectifier
- b. condenser
- c. volume limitation device (VLD)

______6. Computer decisions are made in the ___.

a. Electronic Control Module (ECM)
b. Computer Brain Unit (CBU)
c. Computer Decision Center (CDC)

______7. One function of a diode is to ___.

a. lower resistance in a circuit
b. change AC current to DC
c. increase circuit voltage

______8. Before signals from sensors can be processed by the computer, they must be ___.

a. filtered by the ECM
b. translated into English
c. translated to binary code

______9. Electronic components that receive output from the ECM and adjust the functions of various components are ___.

a. control devices
b. signal receptive devices
c. adjustment devices

______10. Examples of rectifiers are ___.

a. sensors
b. diodes
c. capacitors

______11. Sensors are usually ___.

a. switches
b. diodes
c. resistors

______12. When current passes through the coils of a solenoid ___.

a. an electric charge is produced
b. a magnetic field is generated
c. AC current is changed to DC

______13. An electronic transistor is ___.

a. a three-layer chip
b. a vacuum tube
c. negatively charged

______14. The electronic systems most affected by law are ___.

a. ignition and fuel systems
b. fuel and braking systems
c. ignition and braking systems

______15. Electronic ignition improves emission control, engine performance, and ___.

a. aerodynamics
b. gas combustion
c. electrical system functions

______16. Electronic ignition replaces ___.

a. generators
b. starter solenoids
c. points and condensers

______17. The fuel system can be controlled electronically to react to changes in ___.

a. driver control only
b. speed, altitude, and weather
c. octane and speed

_____18. Diagnostic readout is ___.

a. a paper listing diagnostic results
b. the measurements shown on meters and other test equipment
c. electronic test equipment that links with the onboard computer

_____19. When used in electronic testing, a dwell meter detects ___.

a. continuity
b. open or closed loops
c. valence

_____20. In wiring diagrams, electrical and electronic parts and components are ___.

a. separate and different
b. separate but alike
c. combined

_____21. Electronic control module connections, as displayed in wiring diagrams, are labeled ___.

a. with a letter or number
b. by part number
c. with a color code

_____22. To open wiring connectors, it is best to use a ___.

a. lubricant and pliers
b. special tool
c. screwdriver

_____23. When splicing wires leading to or from electronic components, ___.

a. solder over the crimp, tape the wire, then tape the wiring jacket
b. solder over the crimp and tape
c. use a firm crimp and no solder

_____24. Two types of connectors are ___.

a. weather Pack and Metri-Pack
b. sandwich Pack and Weather Pack
c. metri-Pack and Sandwich Pack

_____25. How much insulation should be removed from wires when replacing connector terminals?

a. 2mm
b. 5mm
c. 10mm

_____26. When replacing a connection terminal, the connections should be ___.

a. crimped and taped
b. crimped, soldered, and taped
c. crimped and soldered

_____27. A ECM replacement is usually accompanied by ___.

a. extensive rewiring
b. transfer of the PROM unit
c. electrical system overhaul

_____28. To remove the ECM ___.

a. unplug connectors and pry it loose with a screwdriver
b. unlock tabs, unplug connectors, and lift carefully
c. requires a special removal tool

_____29. Before replacing the ECM, compare ___.

a. part numbers
b. serial numbers
c. voltage levels

OBJECTIVE 1

Match terms associated with diagnosing electronic system repair requirements to their correct definitions.

- **Binary Code** — A mathematic "language" used by computers

> Binary code uses only two symbols—1 and 0—to represent all other numbers. By sending voltage signals, sensors communicate with the central processing unit. It, in turn, sends voltage signals to control devices. Other numeric codes sent to service professionals through digital readouts, can indicate possible repair procedures or locate trouble spots.

Decimal	Binary	Count
0	0	zero
1	1	one
2	10	two
3	11	three
4	100	four
5	101	five
6	110	six
7	111	seven
8	1000	eight
9	1001	nine
10	1010	ten

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- **Closed-loop** — A computer control system in which the computer continuously monitors and adjusts automotive functions

- **ECM (Electronic Control Module)** sometimes called ECA or ECU — Electronic components that makes decisions and determines output, based on input and programming, for optimum vehicle performance

- **Electronic** — Systems powered and controlled by the flow of electrons through semi-conductors

- **Input** — Signals sent from the sensor to the ECM

- **Open-loop** — A computer control system in which engine functions are guided by a preset program

  EXAMPLE: Engine start-up

- **Output** — Command signals sent from the ECM to a control device

- **Semi-conductor** — An atom with four electrons in its outer shell

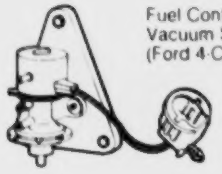
  NOTE: A conductor has fewer than four electrons in its outer shell; an insulator more than four.

OBJECTIVE 2 **Complete statements about electronic parts and components.** (Supplements 1, 2, & 3; Job Sheet 1)

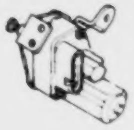
- **Capacitors/Condensers** — Electronic parts made of two plates of conductive material separated by an insulator; a capacitor/condenser stores energy in an electrostatic field

- **Control Devices** — (Sometimes called output devices or servomechanisms) Electronic components that receive signals from the ECM then adjust the functions of various components and systems

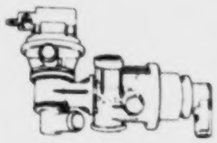
  Typical Control Units



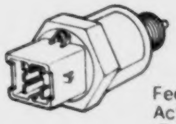
Fuel Control
Vacuum Solenoid
(Ford 4-Cyl MCU)



Idle Speed Control
(ISC) Motor
(GM)



Air Switching
Valve
(GM)



Feedback Control
Actuator (FCA)
(Ford)

Used with permission of Mitchell International.

- **Diodes** — Electronic parts made of a two-layer chip used to change or rectify AC current to DC or to control voltage output
- **Input/Output Devices** — Part of the ECM; electronic components that send and receive voltage signals to and from the ECM
- **Rectifiers** — An electronic device that converts AC to DC current (i.e., diode)
- **Sensors** — Variable resistors that send voltage signals to and receive voltage signals from the ECM, reflecting the performance of the connected component
- **Solenoids** — A solenoid is an electrical part made of a hollow tube wrapped in coils of wire; when current passes through the coils, a strong magnetic field is generated within the tube
- **Switches** — "On/off" devices that provide input to the ECM, much like a sensor
- **Transistors** — Electronic switches or relays made of three-layer chips that vary conductivity according to voltage and current

  NOTE: The number of sensors, switches, and other components will vary among makes and models, depending upon the complexity of the electronic system. A more detailed listing of sensors is in Supplement 1.

OBJECTIVE 3

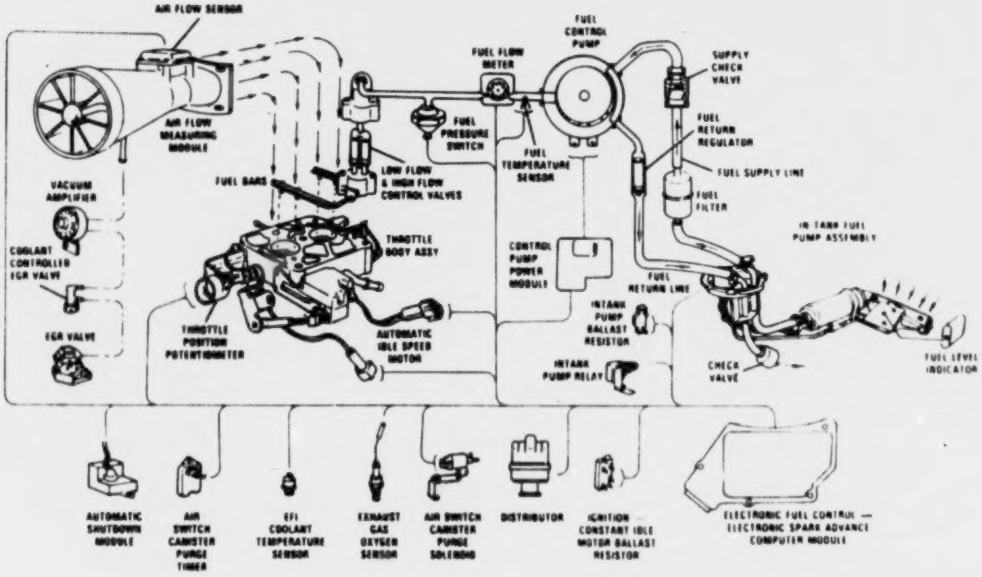
List major electronic systems.

NOTE: Virtually every automotive system may use electronic components. Many systems are monitored or controlled by them, while others may contain some electronic components without being linked to the computer.

EXAMPLES: Computer-controlled automatic transmissions, anti-lock braking systems, computer adjusted level control, electronic accelerator linkage, and a computer-controlled suspension system

- **Ignition** — Electronic ignition systems allow better control of emissions, enhance engine performance, reduce the need for maintenance, and produces a more efficient burning of combustion gasses. They replace point condensers of older systems. Electronic ignition systems are used extensively because emission control laws have become stricter.
- **Fuel** — Air, fuel mixtures, ignition, and timing can all be controlled electronically to react to changes in speed, altitude, and even weather. This continuous monitoring and adjusting insures peak vehicle performance, increases mileage, and reduces toxic emission.

Computer Controlled Components


AIR FLOW SENSOR
AIR FLOW MEASURING MODULE
VACUUM AMPLIFIER
COOLANT CONTROLLED EGR VALVE
EGR VALVE
FUEL BARS
LOW FLOW & HIGH FLOW CONTROL VALVES
FUEL FLOW METER
FUEL PRESSURE SWITCH
FUEL CONTROL PUMP
FUEL TEMPERATURE SENSOR
SUPPLY CHECK VALVE
FUEL RETURN REGULATOR
FUEL SUPPLY LINE
FUEL FILTER
IN TANK FUEL PUMP ASSEMBLY
THROTTLE BODY ASSY
CONTROL PUMP POWER MODULE
FUEL RETURN LINE
INTANK PUMP BALLAST RESISTOR
THROTTLE POSITION POTENTIOMETER
AUTOMATIC IDLE SPEED MOTOR
INTANK PUMP RELAY
CHECK VALVE
FUEL LEVEL INDICATOR
AUTOMATIC SHUTDOWN MODULE
AIR SWITCH CANISTER PURGE TIMER
EFI COOLANT TEMPERATURE SENSOR
EXHAUST GAS OXYGEN SENSOR
AIR SWITCH CANISTER PURGE SOLENOID
DISTRIBUTOR
IGNITION — CONSTANT IDLE MOTOR BALLAST RESISTOR
ELECTRONIC FUEL CONTROL — ELECTRONIC SPARK ADVANCE COMPUTER MODULE

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- **Driver information and comfort** — From clocks and stereo systems, to electronic locks, to map information, the driver's comfort is increasingly electronically based. Maintenance and repair information based on continuous monitoring is available to the driver instantaneously.

OBJECTIVE 4

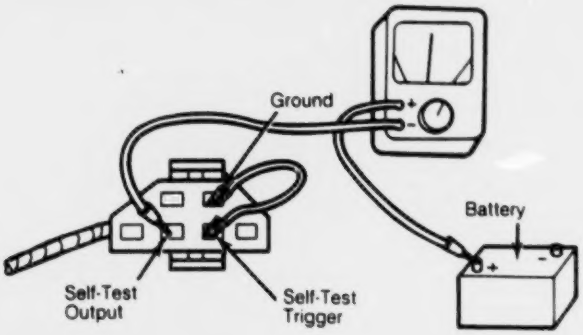
Label electronic test equipment.

CAUTION

Test equipment requirements and procedures vary with makes and models. Do not test or replace electronic parts unless the recommended equipment and tools are used. Always follow procedures in the appropriate manual.

- **Circuit test lamp**

A test lamp is used to test for continuity. An unpowered test lamp is used when testing circuits containing electronic components. Use of a 12-volt or self-powered lamp may damage components. The test light is used just as it was for electrical circuits: one lead is grounded the other attached to the circuit. If the light comes on, the circuit is complete.

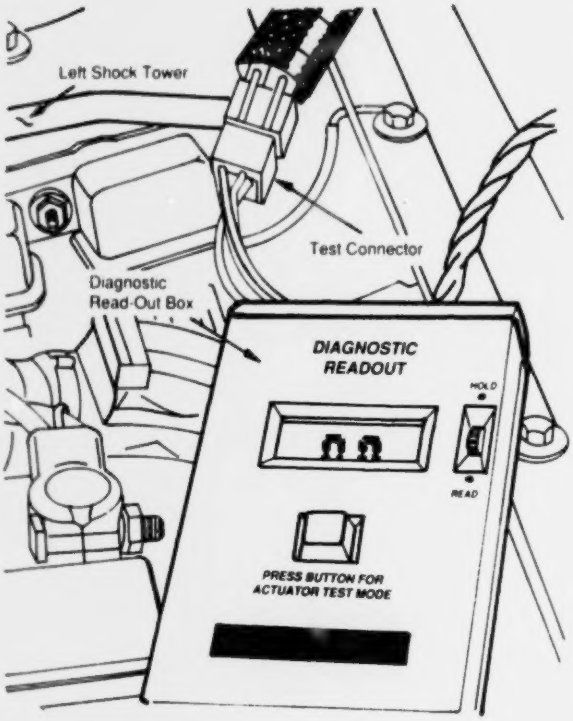


Service codes are shown by voltage pulses. The first digit is indicated by a series of pulses, then the needle drops to zero for 2 seconds, then the second digit of the code is displayed. After all service codes are displayed, the throttle kicker will retract.

Used with permission of Mitchell International.

- **Diagnostic readout (Scanners)**

Specialized electronic test equipment that links with the onboard computer system, analyzes input, and provides service or repair codes.


Left Shock Tower
Test Connector
Diagnostic Read-Out Box
DIAGNOSTIC READOUT
HOLD
READ
PRESS BUTTON FOR ACTUATOR TEST MODE

Used with permission of Chrysler Corporation.

Readout equipment varies among auto-makers. Some equipment is small and handheld, other equipment may be large and elaborate.

- **Digital voltmeter**

A voltmeter is used to measure circuit voltage. Analog voltmeters are not capable of the precise measurements needed in electronic testing and may damage delicate computer circuits.

- **Dwell meter**

The dwell meter is used to test for open- or closed- loop status, not dwell. It must be set to the six-cylinder scale. Some dwell meters will not work for electronic testing procedures.

- **Hand-held vacuum pump**

The hand-held vacuum pump is used to test vacuum- or air-operated output devices by producing ("pulling") a vacuum.

- **Jumper wires**

Just as in electrical circuitry, a set of jumper wires can be used to test for continuity. By jumping an electronic load, the status of that load can be determined.

- **Ohmmeter**

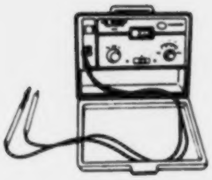
An ohmmeter is used to measure resistance in electronic circuitry, electronic devices, and in circuits containing electronic components.

- **Vacuum gauge**

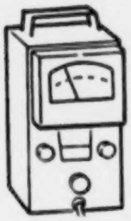
The vacuum gauge is used to check the system for vacuum leaks by connecting the gauge and monitoring vacuum dissipation.

Testing Equipment

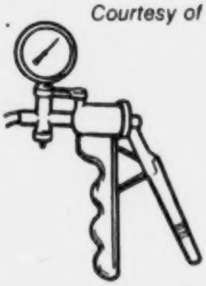
Courtesy of General Motors Corp



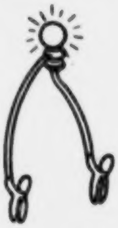
Digital Volt/Ohmmeter
(10-Megohm Input Impedance)



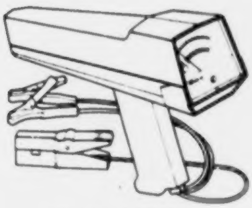
Dwell Meter



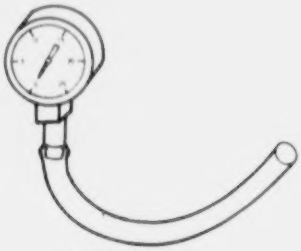
Vacuum Pump
With Gauge



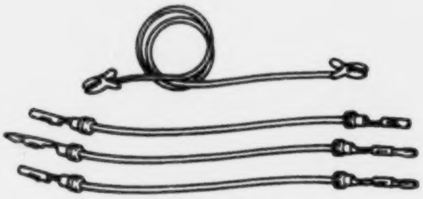
Test Light



Timing Light



Vacuum Gauge



Jumper Wires

NOTE: A complete visual check and thorough knowledge of all automotive systems are the most basic tools in testing electronics.

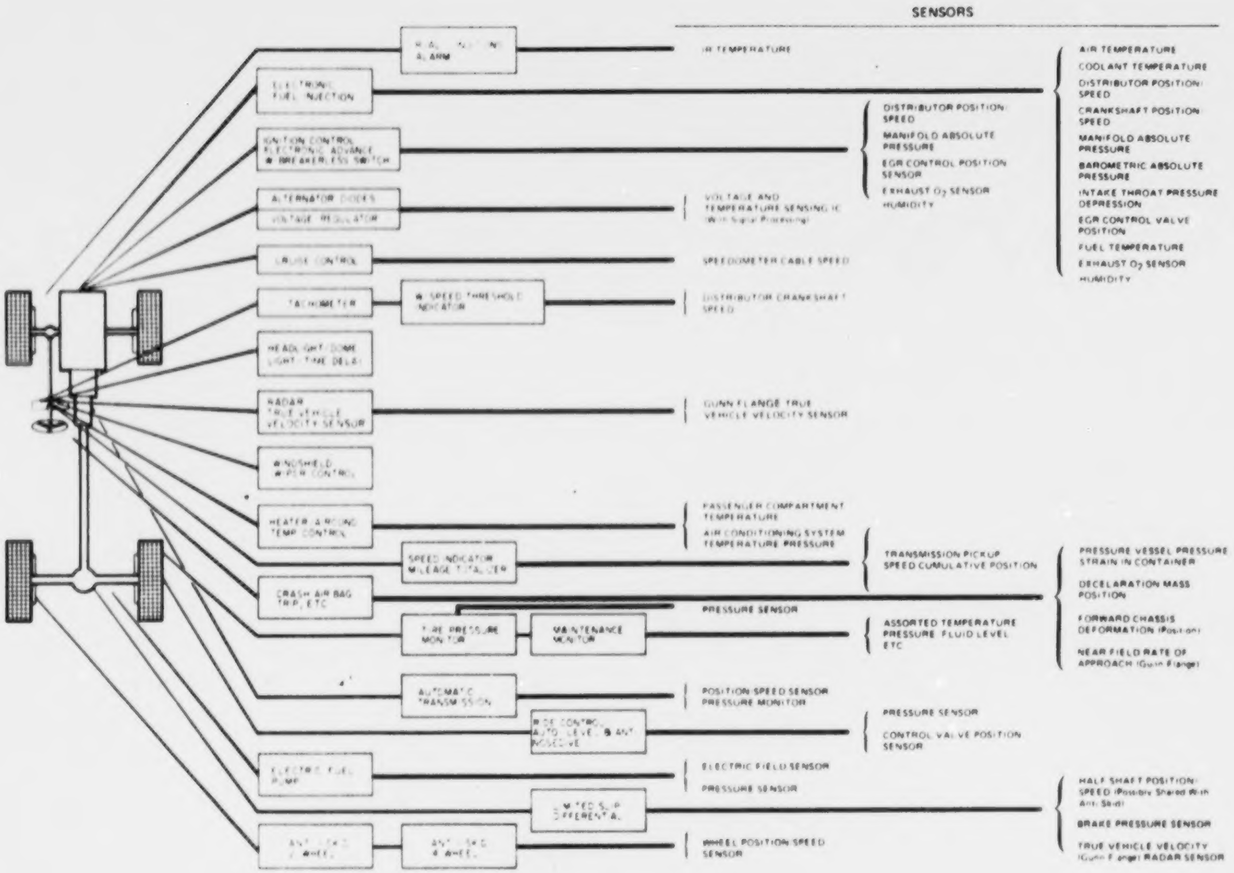

SENSORS
ALARM
IR TEMPERATURE
ELECTRONIC FUEL INJECTION
IGNITION CONTROL ELECTRONIC ADVANCE & BREAKERLESS SWITCH
ALTERNATOR DIODES
VOLTAGE REGULATOR
VOLTAGE AND TEMPERATURE SENSING IC (With Signal Processing)
CRUISE CONTROL
SPEEDOMETER CABLE SPEED
TACHOMETER
& SPEED THRESHOLD INDICATOR
DISTRIBUTOR CRANKSHAFT SPEED
HEADLIGHT/DOME LIGHT TIME DELAY
RADAR TRUE VEHICLE VELOCITY SENSOR
GUNN FLANGE TRUE VEHICLE VELOCITY SENSOR
WINDSHIELD WIPER CONTROL
HEATER AIRCOND TEMP CONTROL
PASSENGER COMPARTMENT TEMPERATURE
AIR CONDITIONING SYSTEM TEMPERATURE PRESSURE
SPEED INDICATOR MILEAGE TOTALIZER
TRANSMISSION PICKUP SPEED CUMULATIVE POSITION
CRASH AIR BAG TRIP, ETC
PRESSURE SENSOR
TIRE PRESSURE MONITOR
MAINTENANCE MONITOR
ASSORTED TEMPERATURE PRESSURE FLUID LEVEL ETC
AUTOMATIC TRANSMISSION
POSITION SPEED SENSOR
PRESSURE MONITOR
RIDE CONTROL, AUTO LEVEL & ANTI NOSEDIVE
PRESSURE SENSOR
CONTROL VALVE POSITION SENSOR
ELECTRIC FUEL PUMP
ELECTRIC FIELD SENSOR
PRESSURE SENSOR
LIMITED SLIP DIFFERENTIAL
ANTI-SKID 2 WHEEL
ANTI-SKID 4 WHEEL
WHEEL POSITION/SPEED SENSOR
DISTRIBUTOR POSITION/SPEED
MANIFOLD ABSOLUTE PRESSURE
EGR CONTROL POSITION SENSOR
EXHAUST O2 SENSOR
HUMIDITY
AIR TEMPERATURE
COOLANT TEMPERATURE
DISTRIBUTOR POSITION/SPEED
CRANKSHAFT POSITION/SPEED
MANIFOLD ABSOLUTE PRESSURE
BAROMETRIC ABSOLUTE PRESSURE
INTAKE THROAT PRESSURE DEPRESSION
EGR CONTROL VALVE POSITION
FUEL TEMPERATURE
EXHAUST O2 SENSOR
HUMIDITY
PRESSURE VESSEL PRESSURE STRAIN IN CONTAINER
DECELARATION MASS POSITION
FORWARD CHASSIS DEFORMATION (Position)
NEAR FIELD RATE OF APPROACH (Gunn Flange)
HALF SHAFT POSITION/SPEED (Possibly Shared With Anti-Skid)
BRAKE PRESSURE SENSOR
TRUE VEHICLE VELOCITY (Gunn Flange) RADAR SENSOR

Figure 1 (b). Sensor Applications

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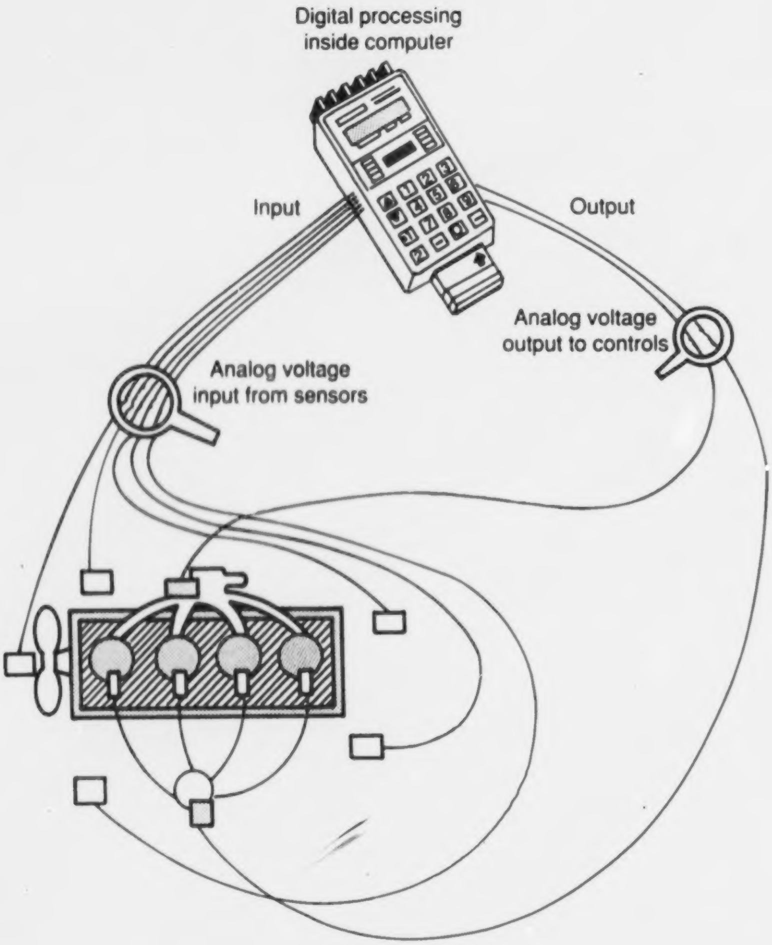
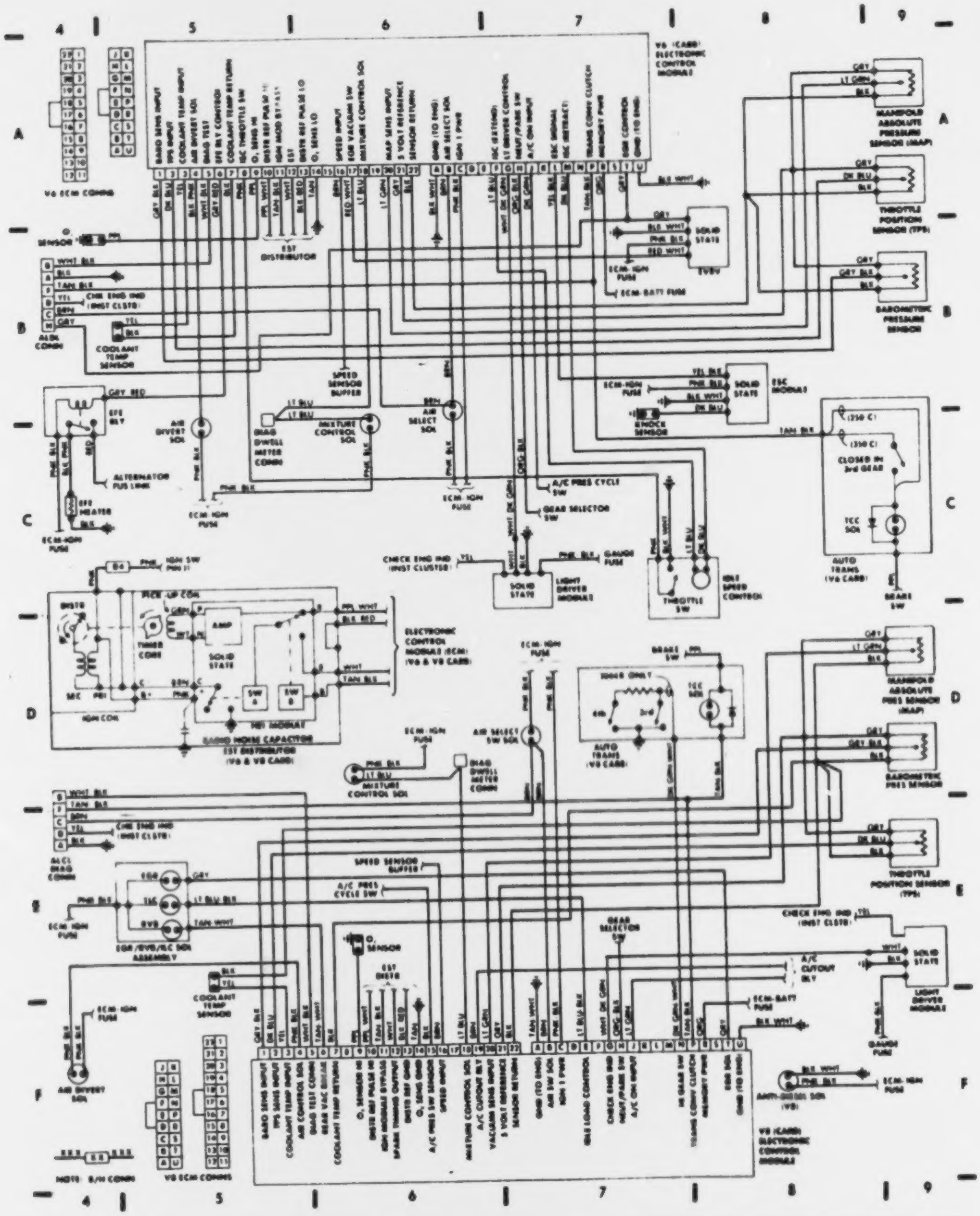
HOW COMPUTERS MONITOR AND ADJUST AUTOMOTIVE SYSTEMS


Digital processing inside computer
Input
Output
Analog voltage output to controls
Analog voltage input from sensors


V6 (CARB) ELECTRONIC CONTROL MODULE
V6 ECM CONN
MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)
THROTTLE POSITION SENSOR (TPS)
BAROMETRIC PRESSURE SENSOR
COOLANT TEMP SENSOR
ALDL CONN
SPEED SENSOR BUFFER
ESC MODULE
KNOCK SENSOR
AIR DIVERT SOL
MIXTURE CONTROL SOL
AIR SELECT SOL
DIAG DWELL METER CONN
ALTERNATOR FUS LINK
EFE HEATER
ECM IGN FUSE
A/C PRES CYCLE SW
GEAR SELECTOR SW
CHECK ENG IND (INST CLUSTER)
LIGHT DRIVER MODULE
THROTTLE SW
IDLE SPEED CONTROL
AUTO TRANS (V6 CARB)
BRAKE SW
TCC SOL
ELECTRONIC CONTROL MODULE (ECM) (V6 & V8 CARB)
PICK UP COIL
TIMER CORE
SOLID STATE
IGN COIL
HEI MODULE
RADIO NOISE CAPACITOR
EST DISTRIBUTOR (V6 & V8 CARB)
EGR/EVS/ILC SOL ASSEMBLY
O2 SENSOR
A/C CUTOUT RLY
GAUGE FUSE
ECM BATT FUSE
ANTI-DIESEL SOL (V8)
V8 (CARB) ELECTRONIC CONTROL MODULE
V8 ECM CONN
4
5
6
7
8
9
A
B
C
D
E
F

ENGINE COMPARTMENT

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KEY TO WIRING DIAGRAM

HOW TO USE THE NEW DIAGRAMS

1) The front part of the diagram contains a reference list of the major electrical components. Find the component or system you wish to trace.

2) Use the grid numbers and letters to find the component on the wiring diagram pages.

3) The vehicle locations shown at the bottom of the page will help you to find the approximate location of the component on the actual vehicle.

4) Find the circuit you need to service. The internals are shown for switches and relays so you can understand how the circuit operates.

5) If the wires are not drawn all the way to another component, a reference will tell you their destination.

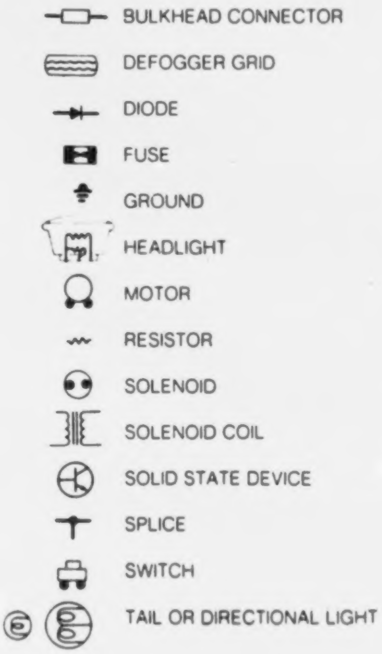
6) Use the reference list and grid to find the other component rather than tracing a wire through several pages.

COLOR ABBREVIATIONS

Color	Normal	Optional
BLACK	BLK	BK
BLUE	BLU	BU
BROWN	BRN	BN
CLEAR OR COLORLESS	CLR	CR
DARK BLUE	DK BLU	DK BU
DARK GREEN	DK GRN	DK GN
GREEN	GRN	GN
GRAY	GRY	GY
LIGHT BLUE	LT BLU	LT BU
LIGHT GREEN	LT GRN	LT GN
ORANGE	ORG	OG
PINK	PNK	PK
PURPLE	PPL	PL
RED	RED	RD
TAN	TAN	TN
VIOLET	VIO	VI
WHITE	WHT	WT
YELLOW	YEL	YL

WIRING SYMBOLS

Standard wiring symbols are used on our diagrams. The list below will help clarify any symbols that are not easily understood at a glance. Most components are labeled "Motor", "Switch" or "Relay" in addition to being drawn with the standard symbol.


BULKHEAD CONNECTOR
DEFOGGER GRID
DIODE
FUSE
GROUND
HEADLIGHT
MOTOR
RESISTOR
SOLENOID
SOLENOID COIL
SOLID STATE DEVICE
SPLICE
SWITCH
TAIL OR DIRECTIONAL LIGHT

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FIND SENSORS

Locate all the sensors in your car by checking a service manual and wiring diagram. List the sensors and their purposes.

ACTIVITY SHEET 2

ELECTRONIC SYSTEM REPAIR REQUIREMENTS

REPORT ON ELECTRONIC APPLICATIONS IN AUTOMOTIVE DESIGN

Visit an auto showroom, read an article in an automobile magazine, or talk to an electronic repair specialist. Find out how electronics have affected automotive design and what changes we will see in the future. Then do one of the projects below:

WRITE A REPORT ABOUT ELECTRONIC APPLICATIONS IN AUTOMOTIVE DESIGN

Write a two-page report about what you discovered. Include information about how today's cars use electronics and what electronic features tomorrow's cars will include.

or

MAKE A "BEFORE AND AFTER" DISPLAY

Make a model or diagram of an electronic system before electronics and after. Label them, including differences and improvements.

or

DESIGN THE CAR OF THE FUTURE

Make a model or draw a picture of the car of the future. Label it, explaining its capabilities and how electronics are used.

ASSIGNMENT SHEET 1

ELECTRONIC SYSTEM REPAIR REQUIREMENTS

II

NAME ______________________________ SCORE ______

OBJECTIVE 5

Interpret wiring diagrams.

INTRODUCTION

Electronic devices are included in wiring diagrams alongside electrical parts and components. Symbols for electronic components may be found in the key at the front of the service manual.

One difference is the inclusion of control modules and electronic connections. These blocks are labeled in the wiring diagram, and each connection is labeled with a letter or number.

DIRECTIONS

Use the wiring diagram in Supplement 3 to answer the questions below.

1. Terminal "A" on the ALCL Diagnostic Connector leads to a ______.
2. Terminal "L" of the V6 (Carb) Electronic Control Module is connected to a yellow/black wire that leads to the solid state Esc Module. What type of sensor controls that module?
3. What assembly includes three solenoids?
4. In section D-6 of the diagram, we see that the EST distributor is connected to the Electronic Control Module (ECM). What connectors on the ECM are used for this connection?
5. What component is included in the Manifold Absolute Pressure Sensor, Barometric Pressure Sensor, and Throttle Position Sensor?
6. The Idle Speed Control includes what components?

ASSIGNMENT SHEET 1

1. ground
2. knock sensor
3. EGR/RVB/ILC Solenoid assembly
4. 10, 11, 12, 13
5. variable resistors
6. a switch and a motor

OBJECTIVE 6a

Remove and install Metri-Pack and Weather-Pack connectors.

INTRODUCTION

It has been estimated that more than 90% of all electrical or electronic problems are caused by poor electrical connections. Electronic connectors can become damaged due to oxidation, extreme humidity, or dust. If damaged, the connectors may cause intermittent problems, open circuits, or false computer readings.

METRI-PACK CONNECTOR

TOOLS AND EQUIPMENT

- Service manual
- Wire repair kit with terminal removing tools
- Soldering pencil
- Safety glasses
- Fender covers

CAUTION

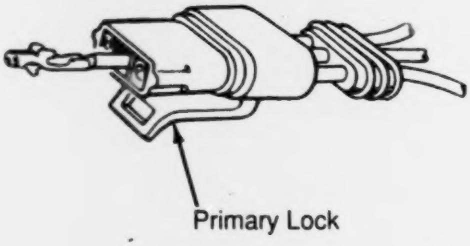
Many connectors require the use of special tools (found in the wiring kit). Do not use a screwdriver or other substitute.

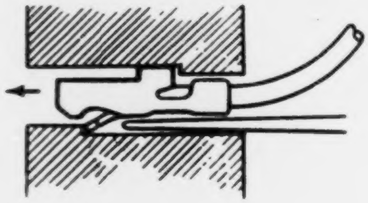
PROCEDURE

1. Locate service manual.
2. Place the car in park if it is an automatic; neutral if it is a standard.
3. Set the parking brake on.
4. Turn off the ignition.
5. Open hood and install fender covers.
6. Locate the connector you are to repair, using wiring diagrams in the service manual.
7. Disconnect the primary and secondary locks of the connector.
8. Remove the old terminal assembly with terminal removal tool.
9. Remove 5 mm (0.2 inch) of the insulation.
10. Clean the connector's terminal cavity.

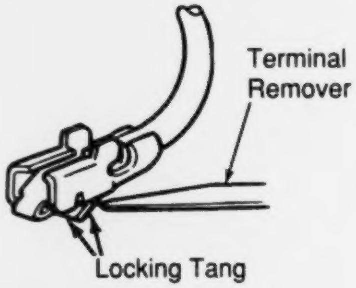
11. Slide the insulator back about 8 cm on the wire.

Metri-Pack Connector


Primary Lock



VIEW A


Terminal
Remover
Locking Tang

VIEW B

Used with permission of General Motors Corporation.

12. Install the terminal on the wire.

13. Roll crimp and solder the terminal.

14. Slide the terminal insulator to the terminal and roll crimp.

15. Press the terminal into the connector and connect the secondary lock.

16. Have your instructor check your work.

17. Put away tools and materials and clean the work area.

WEATHER PACK CONNECTOR

TOOLS AND EQUIPMENT

- Service manual
- Required terminal remover
- Service manual
- Crimping tool
- Replacement connector
- Soldering pencil
- Rosin core solder
- Fender covers
- Safety glasses

PROCEDURE

1. Locate service manual.

2. Place the car in park if it is an automatic; neutral" if it is a standard.

3. Set the parking brake on.

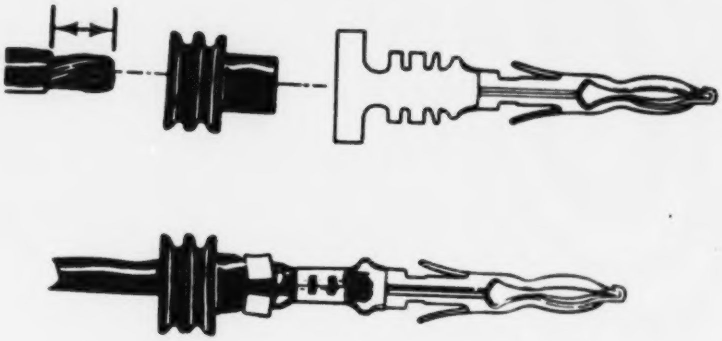
4. Turn off the ignition.

5. Open hood and install fender covers.

6. Locate the connector you are to repair, using wiring diagrams in the service manual.

7. Disconnect the primary lock and disconnect the connector body.

Weather-Pack Connector



Used with permission of General Motors Corporation.

8. Disconnect the connector seal. Pull it back away from the connector body and onto the wire.

9. Insert the terminal connector into the connector body and depress the locking tang. Push or pull wire and terminal through the connector body.

10. Snip off the old terminal.

11. Remove 5 mm of the wire insulation.

12. Clean the terminal connector body cavity.

13. Place the terminal on the wire, crimp, and solder.

14. Pull the wire on the connector's seal side until the locking tang is fully seated.

15. Press the seal into the connector body until primary lock engages.

16. Reconnect terminals.

17. Have your instructor check your work.

18. Put away tools and materials and clean work area.

OBJECTIVE 6b

Splice wiring.

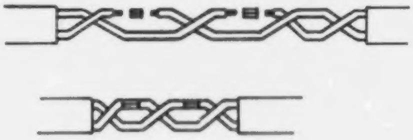
TOOLS AND EQUIPMENT

- Service manual
- Splice clips
- Crimping tool
- Soldering pencil
- Rosin core solder
- Electrical tape
- Fender covers
- Safety glasses

PROCEDURE

NOTE: When splicing wires, consider the stress placed on wire and the location of other splices. If these splices increase tension on the wire, add 6-8 inches of new wire into the circuit. Splices should not be opposite each other. Instead, remove a portion of the wire and stagger splices. At least 1½" of wire should be in place between splices.

1. Locate service manual.
2. Place the car in park if it is an automatic, in neutral if it is a standard.
3. Set the parking brake on.
4. Open the hood and locate the wire to be repaired.
5. Check the circuit for special situations; read repair procedures.
6. Remove a portion of the wire jacket.
7. Pull the affected wires into the open.
8. Remove insulation from the wire ends.

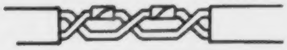


9. Place a splice clip on the wire, leaving some exposed wire on each side.

10. Crimp the splice clip in place.

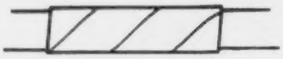
11. Solder the splice, covering all exposed wire.

12. Wrap the splice with electrical tape.



13. Pull wires back into the jacket.

14. Wrap the wiring jacket with electrical tape.



15. Have your instructor check your work.

16. Put away tools and materials and clean the work area.

150

PRACTICAL TEST 1

ELECTRONIC SYSTEM REPAIR REQUIREMENTS II

JOB SHEET 1

Remove and install Metric-Pack and Weather-Pack connectors.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. __

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Located the proper connectors.	_____	_____
2. Followed appropriate directions for unlocking and disconnecting the Metri-Pack connector.	_____	_____
3. Removed terminal successfully.	_____	_____
4. Removed proper amounts of insulation.	_____	_____
5. Crimped and soldered Metri-Pack terminal.	_____	_____
6. Replaced terminal and firmly locked it.	_____	_____
7. Depressed then reshaped Weather Pack locking tang.	_____	_____
8. Crimped and soldered Weather Pack terminal.	_____	_____

		YES	NO
9.	Reseated locking tang and engaged primary lock on Weather Pack connector.	_____	_____
10.	Used proper tools correctly.	_____	_____
11.	Performed steps in a timely manner.	_____	_____
12.	Practiced safety rules throughout procedure.	_____	_____
13.	Provided satisfactory responses to questions asked.	_____	_____
14.	Put away tools and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Located proper connector using wiring diagrams quickly and easily	4	3	2	1
Removed old terminal assembly	4	3	2	1
Removed insulation cleanly and without damaging wire	4	3	2	1
Cleaned terminal cavities completely	4	3	2	1
Crimped terminals firmly and cleanly	4	3	2	1
Covered crimp in good, even layer of solder	4	3	2	1
Refastened all connector locks	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 2

ELECTRONIC SYSTEM REPAIR REQUIREMENTS

II

JOB SHEET 2

Splice wiring.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Removed an adequate amount of the wiring jacket without damaging the wire.	_____	_____
2. Removed insulation from each wire without damaging wire.	_____	_____
3. Crimped the splice in place adequately.	_____	_____
4. Soldered crimp, covering all exposed wire.	_____	_____
5. Wrapped wire with electrical tape.	_____	_____
6. Returned wire to jacket.	_____	_____
7. Taped jacket.	_____	_____
8. Used proper tools correctly.	_____	_____
9. Performed steps in a timely manner.	_____	_____
10. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
11. Provided satisfactory responses to questions asked.	____	____
12. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Removed an adequate amount of wiring jacket with no damage to insulation	4	3	2	1
Properly placed splice clip	4	3	2	1
Crimped and soldered cleanly and completely	4	3	2	1
Wrapped wire firmly/evenly	4	3	2	1
Placed wire in jacket and taped cleanly	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

ELECTRONIC SYSTEM REPAIR REQUIREMENTS II

NAME ______________________________ SCORE ________

OBJECTIVE 1

Match terms associated with diagnosing electronic system repair requirements to their definitions. Write the correct letters in the blanks.

______1. Command signals sent from the ECM to a control device

______2. Signals sent from the sensor to the ECM

______3. A computer control system in which the computer continuously monitors and adjusts automotive functions

______4. Systems powered and controlled by the flow of electrons through a semi-conductor

______5. An atom with four electrons in its outer shell

______6. A computer control system in which engine functions are guided by a preset program

a. Commands

b. Closed-loop

c. Electronic

d. Input

e. Logic

f. Magnetic

g. Open-loop

h. Output

i. Semi-conductor

OBJECTIVE 2

Complete statements about electronic parts and components.

1. The ECM is an electronic component that makes decisions, based on ____________ and ______________________, to maintain optimum vehicle performance.
2. Diodes can be used to ______________________________ or to ______________________________________.

3. Electronic control devices receive messages from the

_________.

4. Transistors are made of __________ -layer chips.

5. Some sensors are _________________ resistors.

6. Electronic devices like and diodes convert AC current to DC and are called __________________.

7. A solenoid is made of a ______________________ wrapped with coils of wire.

8. Switches provide the ECM with __________.

OBJECTIVE 3 **List major electronic systems.**

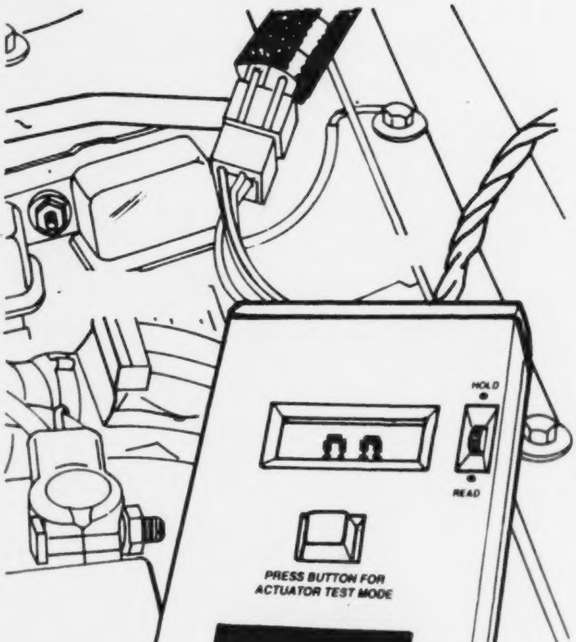
1. ______________________________________

2. ______________________________________

3. ______________________________________

OBJECTIVE 4 **Label electronic test equipment.**

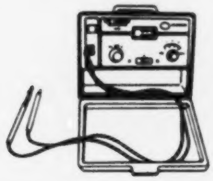
a. ______________


HOLD
READ
PRESS BUTTON FOR ACTUATOR TEST MODE

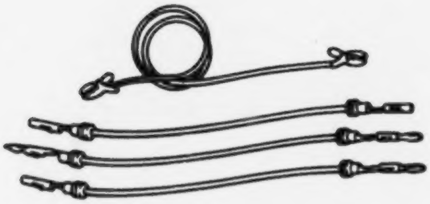
b. ______________________________

or

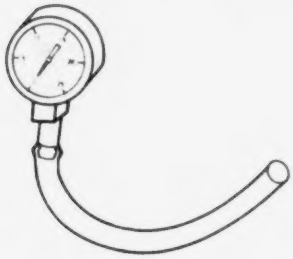
____



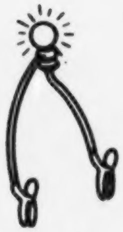
c. ______________________________



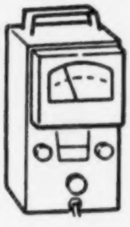
d. ______________________________



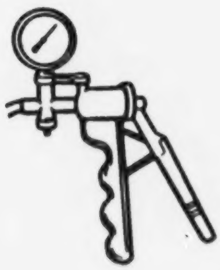
e. ______________________________



f. ______________________________



g. ______________________________



NOTICE The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.

OBJECTIVE 5	**Interpret wiring diagram.**	SCORE ______
OBJECTIVE 6a	**Remove and install Metri-Pack and Weather-Pack connectors.**	RATING ______
OBJECTIVE 6b	**Splice wiring.**	RATING ______

WRITTEN TEST ANSWERS

ELECTRONIC SYSTEM REPAIR REQUIREMENTS II

OBJECTIVE 1

1. h
2. d
3. b
4. c
5. i
6. g

OBJECTIVE 2

1. Input and programming
2. Change (rectify) AC current to DC
   Control voltage output
3. ECM
4. 3
5. Variable
6. Rectifiers
7. A hollow tube
8. Binary
9. Input

OBJECTIVE 3

Answers should include the following:
- Fuel
- Ignition
- Driver information and comfort

OBJECTIVE 4

a. Diagnostic readout
b. Digital voltmeter or ohmmeter
c. Jumper wires
d. Vacuum gauge
e. Circuit test lamp
f. Dwell meter
g. Hand-held vacuum pump

OBJECTIVE 5

Refer to Answers to Assignment Sheet 1.

OBJECTIVE 6

Refer to Practical Tests 1-2.

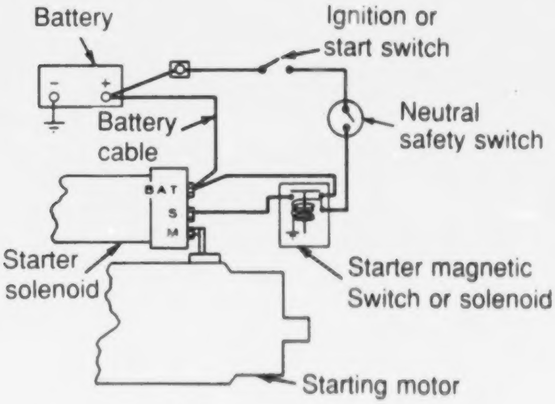
OBJECTIVE SHEET

STARTING SYSTEM

III

INTRODUCTION

Early automobiles had to be started with a hand crank. This required patience, strength, and a lot of "elbow grease," even for the simple systems used at that time. Today's complex systems could not possibly be started using a hand crank. Fortunately, in 1912 engineer Charles Kettering invented the self-starter. With this system, we can start multicylinder engines with the simple turn of a key.


Battery
Ignition or start switch
Battery cable
Neutral safety switch
BAT
S
M
Starter solenoid
Starter magnetic Switch or solenoid
Starting motor

UNIT OBJECTIVE

After completing this unit, the student should be familiar with terms and definitions related to servicing starting systems; know starting system components, functions, types, parts and locations; and be able to describe how a starter operates. The student should be able to test, diagnose problems, and perform basic service on the starter. The student will demonstrate these competencies by completing an assignments sheet, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated to servicing starting systems to their definitions.
2. Draw a diagram of the starting system.
3. Describe the functions of starting system components.
4. Distinguish among types of starters.
5. List parts of a starter.

6. Describe how a starter operates.

7. Distinguish between in-car and bench starter tests.

8. Diagnose starting system problems. (Assignment Sheet 1)

9. Demonstrate the ability to:

    a. Test the starting system. (Job Sheet 1)

    b. Remove and replace a starter. (Job Sheet 2)

    c. Disassemble and bench test a starter. (Job Sheet 3)

    d. Test armature.

STARTING SYSTEM

PREPARATION

- Review unit and plan presentation.
- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.
- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.
- Review teaching suggestions and plan classroom activities.
- Determine how you will schedule time for students to demonstrate competence in the required procedures.
- Order materials to supplement unit.
- Invite a service professional to speak to the class about the tests and procedures related to the starting system.

  NOTE: Supply guest speakers with the Objective Sheet, Information Sheet and any other components you want them to cover.

DELIVERY

Objective 1 Match terms associated to servicing starting systems to their definitions.

- Include additional terms used during instruction, as needed.
- As the students disassemble and reassemble the starters, have them review the name and function of starting system part and component.

Objective 2 Draw a diagram of the starting system.

- Trace the flow of current through the system.
- Review design changes in starter system components. Discuss changes in solenoid design, other types of switch which have been used, etc.
- Discuss the changes in the starting system that we may see in the future.

- Allow students to trace the starting system in schematics and on a variety of cars.

- Have students complete Activity Sheet 1.

Objective 3 Describe the functions of starting system components.

- Have students list the "input" and "output" of each component.

- As each component is discussed, have students suggest the result of failure in that component.

- Be sure students understand the function of each component before moving on to the next component.

- Have students use parts books and service manuals to compare components. The variety of solenoids and starters should be discussed and differences noted.

- As much as possible, students should be allowed to inspect the parts. Hands-on familiarity with the parts and how they operate will increase their understanding of the total system.

Objective 4 Distinguish among types of starters.

- Show students examples of each type of starter listed.

- Have students use parts catalogs to locate an example of each type of starter listed.

- As students disassemble starters, have them categorize the starter by type of circuit and drive mechanism.

Objective 5 List parts of a starter.

- The objective lists only basic parts. Add to the list any parts you feel the students should be tested over.

- Have the students find all the parts listed in an exploded view of a starter.

- As students disassemble starters, have them identify all the parts listed in this objective.

- Have students inspect starters. Discuss how the parts work and how they are connected.

Objective 6 Describe how a starter operates.

- Have students trace the flow of energy through the starter. Explain to them that electrical energy goes into the starter, but mechanical energy goes from it.
- Some discussion of magnetism is necessary. Review electromagnetism, attraction/repulsion of charges, and using magnets and wire loops to produce a charge.
- Have students trace the operation of a starter while disassembling a starter. Have them point to the actual part and explain what it will do.
- Have students complete Assignment Sheet 1 and Job Sheet 1.

Objective 7 Distinguish between in-car and bench starter tests.

- Discuss the need to use service manuals for appropriate testing, test procedures, and interpreting test results.
- Have students complete Job Sheets 2, 3, and 4.
- Have students examine repair manuals for other possible tests and for differences in test procedures between makes and models.
- Discuss test indications and interpretations.

APPLICATION

Objective 8 Diagnose starting system problems.

Objective 9 Demonstrate the ability to:

a. Test the starting system.

b. Remove and replace a starter.

c. Disassemble and bench test a starter.

d. Test armature.

- Have students perform and interpret tests.

- As students test and disassemble components, have them review the names and functions of parts.
- Stress that the service manual is the reference—not this curriculum. Have students compare tests between makes and models and follow all testing instructions listed in the appropriate service manual.
- Have students discuss the purpose of the test. Explain what the test indicates and why.

EVALUATION

Pretest

- Pretest qualifying students.
- Determine individual requirements from pretest results.
- Counsel students individually on pretest results and study requirements.
- Modify materials in unit or create supplementary materials for individual students as required.

Practical test

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.
- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.

- Complete appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Publications

- *Automotive Electricity and Electronics.* Jay Webster wrote a text and workbook combination that covers the fundamentals, batteries, starting, charging, electronic ignition and computerized engine control systems. Order Number 0-02-810230-4 and Instructor's manual, 0-02-810240-1, available from Glencoe/McGraw-Hill, phone 1-800-334-7344.
- *Automobile Electronics and Basic Electrical Systems, Volume I: Basic Text and Volume II: Practice Manual.* By Ken Layne, 1900, this book is a comprehensive theory-practice text covering all automotive electrical fundamentals and systems. Volume II is written in the format of a car maker's service manual, with diagrams, charts and illustrated procedures. Both volumes conform to ASE specifications. Available from Prentice Hall, College Operations, Englewood Cliffs, NJ 07632.

NOTE: General Motors Training Material Merchandising offers the following resources. To order, contact GM Training Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28635 Mound Road, Warren, MI 48029.

- *Batteries, Charging and Cranking* includes "description, operation, diagnosis, disassembly and repair of alternating generators and cranking motors. Emphasizes maintenance-free battery construction, operation, diagnosis and service. Includes 217 page Instructor's Guide and 1 set of 101 overhead transparencies." Order number GM-16021-01M.
- *Batteries, Charging and General* includes "general information; basic electricity. Maintenance-free batteries; Delcotron charging systems; cranking motors." Order number GM-16021-011.
- *Technical Specifications Batteries Charging and Cranking* includes "service bulletins, testing procedures, troubleshooting data and specifications for batteries, charging and starting systems." Order number GM-16021-012.

Computer Software

- *Electrical Ignition System.* For Apple II family computers. Shows students the primary current flow from the ignition switch through a resistor, the primary coil winding, and the transistor in the control module to ground. Shows interruption of the primary current flow, leading to the firing of the appropriate spark plug. Order No. DRW-CG-010A, available from Shopware Education Systems, Department KL-3, 101 Hill Road, Aberdeen, WA 98520-7302, phone (206) 532-3392.

Media

- DCA offers two sets of transparencies, "Starter Construction" and "Starting System Tests" as part of their *Auto Engine Systems* library. To order "Starter Construction" ask for #AES-36. To order "Starting System Tests" as for #AES-37. Additional transparency sets that could be used with this unit are "Magnetism" (AES-31), "Battery Visual Tests" (AES-34) and "Battery Tests" (AES-35). Order by contacting DCA Educational Products Inc., Kellers Church Road, PO Box 338, Bedminister, Pennsylvania, 18910.

- Bergwell offers a 4-part video set, *The Starting System Explained,* (#435X) with tapes on "Field Coil, Armature and Brushes," "The Drive Arrangement and Solenoid," "Starter System Testing," and "Starting Motor Service and Repair." Order from Bergwell Productions, Inc., P.O. Box 238, Garden City, NY, 11530-0238, or call 800-645-3565, Fax # 516-222-9383.

- *Troubleshooting Automotive Electrical Systems.* Four-part filmstrip, and Teacher's Guide. Includes troubleshooting a faulty starter, troubleshooting the starter circuit, introduction to the charging system, and testing Ford charging system. Order No. 31323-127, available from Vocational Media Association, 1-800-431-1242.

- *The Battery and Its Electrical System.* ½" VHS, color, 17 min., 1986. Shows how to install a battery system and how to test the starter, voltage regulator and alternator and discusses battery quality. Order No. VMA31338V, available from Cambridge Vocational and Technical, phone 1-800-468-4227.

UNIT REFERENCES

- *1988 Celebrity Electrical Diagnosis Service Manual Supplement.* General Motors, 1988.
- *1989 Bronco/F150-F350 F-Super Duty Electrical and Vacuum Trouble-Shooting Manual.* Ford Motor Company, 1988.
- deKryger, William J. et al, *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., n.d.
- Duffy, James E., *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- *Auto Electricity, Electronics, Computers.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1990.
- *Fundamentals of Service, Electrical Systems.* Moline, Illinois: John Deere and Company, 1972.
- *Mitchell Electrical Service and Repair Domestic Cars 1987 Supplement.* San Diego, California: Mitchell International, Inc, 1987. Toboldt, William K. and Larry Johnson, *Automotive Encyclopedia.* South Holland, Illinois: The Goodheart-Willcox Company, Inc. 1981.

PRETEST ANSWERS

STARTING SYSTEM

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions

Objective	Question
1	1-5
2	6
3	7-12
4	13-14
5	15-16
6	17-19
7	20
8	21-22
9	23-29

ANSWER KEY

1. a
2. b
3. a
4. c
5. a
6. b
7. b
8. a
9. c
10. c
11. a
12. b
13. a
14. c
15. c
16. b
17. b
18. c
19. b
20. a
21. a
22. c
23. b
24. c
25. a
26. c
27. c
28. b

STARTING SYSTEM

NAME ______________________ SCORE ________

DIRECTIONS

Read the following questions and problems. Circle the letter before the item that best answers the question or solves the problem.

1. An armature is a ___.

   a. series of wire loops
   b. meter for testing amperage
   c. part of the starter housing

2. Current is conducted to the commutator by ___.

   a. bushings
   b. brushes
   c. commutator cable

3. The commutator is made of ___.

   a. copper pieces connected to each armature loop
   b. layers of special metal alloys welded to the starter brushes
   c. copper wire connected to the battery and armature

4. When current passes through the field coils, the pole shoes become ___.

   a. hot
   b. electrically charged
   c. electromagnets

5. Torque can best be defined as ___.

   a. turning power
   b. current power
   c. magnetic power

6. Starting system components include ___.

   a. battery, ignition coil, and solenoid
   b. battery, solenoid, and starter motor
   c. solenoid, starting motor, and ignition coil

7. In the starting system, the battery supplies current to ___.

   a. solenoid and ignition switch
   b. starter motor and ignition switch
   c. solenoid and starter motor

8. The driver controls the starting system through the ___.

   a. ignition switch
   b. driver information panel
   c. CPU

9. The second function of a solenoid is ___.

   a. monitoring current levels in the starter
   b. spinning the armature
   c. shifting the motor pinion and flywheel into engaged position

10. The starting motor ___.

   a. provides current for the engine
   b. controls ignition
   c. cranks the engine

11. The overrunning clutch protects the starter from excessive ___.

   a. engine speed damage
   b. current
   c. resistance

12. When categorized by circuit type, most starters are ___.

    a. series-wound, parallel-wound, or series-parallel wound
    b. series-wound, shunt-type, or compound wound
    c. parallel-wound, shunt-type, or compound wound

13. When categorized by starter drive mechanism, most starters are ___.

    a. direct drive, moveable pole, or solenoid gear reduction
    b. direct drive, moveable pole, or solenoid pole drive
    c. direct solenoid, moveable pole, or direct gear reduction

14. Parts of the starter motor include the ___.

    a. brushes, solenoids, flywheel, and battery cable
    b. battery, battery cable, commutator, and flywheel
    c. brushes, field coils, commutator, and armature

15. Parts and components located along the armature shaft include the ___.

    a. pole shoe and field coils
    b. solenoid and relay
    c. pinion drive gear and overrunning clutch

16. The armature turns because of repulsion between ___.

    a. opposing magnetic charges
    b. like magnetic charges
    c. magnets and metal pieces

17. Within the starter motor, current passes through the ___.

    a. ignition switch, starter motor, and armature shaft
    b. ignition switch, solenoid or relay, brushes, and commutator
    c. battery cable, ignition switch, and pining drive gear

18. Starting system in-car tests include ___.

    a. bench tests and system quick-checks
    b. cranking circuit tests and bench tests
    c. cranking circuit tests and starter draw test

19. Starting system bench tests include ___.

    a. cranking circuit tests, component tests, and load tests
    b. component tests, pinion clearance check, and armature bushing check
    c. component tests, cranking circuit tests, and armature bushing check

20. When diagnosing a starting system problem, perform the tests indicated by ___.

    a. the service manual
    b. noises the car makes
    c. both a and b

21. Any starting system tests should begin with a check of the ___.

    a. battery and cables
    b. solenoid
    c. armature

22. Before a cranking circuit test can be performed, the ___.

    a. battery should be disconnected
    b. engine should be cranked several times
    c. ignition system should be disconnected

23. Measurements made during the cranking circuit test are made with ___.

    a. an ammeter
    b. a voltmeter
    c. an ohmmeter

24. A no-load test reveals ___.

a. resistance through the starting system circuit
b. torque
c. armature revolution speed and current draw

25. When removing a starter, the battery should be ___.

a. disconnected first
b. left connected
c. disconnected only after starter removal

26. When disassembled, a starter should be cleaned with ___.

a. water only
b. water, solvent, and a soft rag
c. air and a soft rag

27. After reassembling a starter, it is wise to ___.

a. check it with a voltmeter
b. check it with a growler
c. attach it to a battery and jumper cables for testing

28. When mounted on a growler, the armature will make a hacksaw blade vibrate if armature loops are ___.

a. intact
b. shorted
c. grounded

INFORMATION SHEET

STARTING SYSTEM

III

OBJECTIVE 1

Match terms associated with servicing starting systems to their correct definitions.

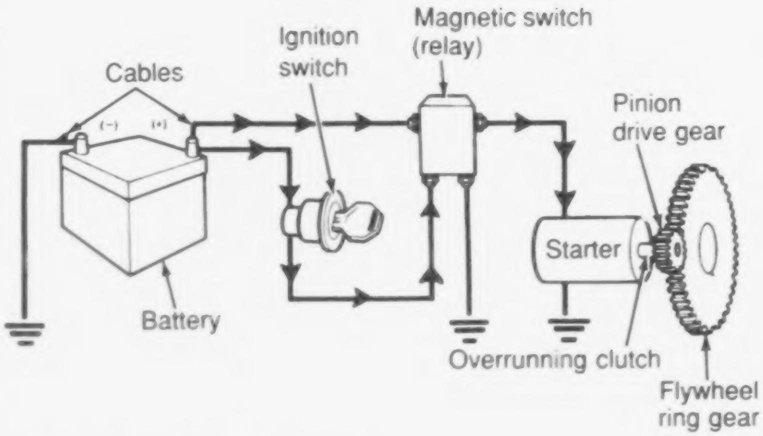
- **Armature** — A series of wire loops surrounded by electromagnets; loops produce a strong electrical current
- **Brushes** — Stationary conductors that transmit current to the commutator
- **Commutator** — Copper pieces connected to each armature loop that transmit and cut off current from the brushes to the armature, providing the alternating polarity needed to turn the armature
- **Field coil** — Coils of wire around the pole shoes. When current passes through the field coils, the pole shoes become electromagnets
- **Pole shoes** — Magnets in the starter field frame
- **Relay** — An electromagnetic switch that completes a circuit
- **Solenoid** — An electromagnetic component that converts electrical power to mechanical action
- **Torque** — Turning power

OBJECTIVE 2

Draw a diagram of the starting system.

- Components
  - Battery
  - Ignition Switch
  - Battery cables
  - Magnetic switch (relay)
  - Solenoid
  - Overrunning clutch

  - Pinion drive gear
  - Neutral safety switch
- Starting system circuit


Cables
(−)
(+)
Ignition switch
Magnetic switch (relay)
Pinion drive gear
Starter
Battery
Overrunning clutch
Flywheel ring gear

Used with permission of Chrysler Corporation.

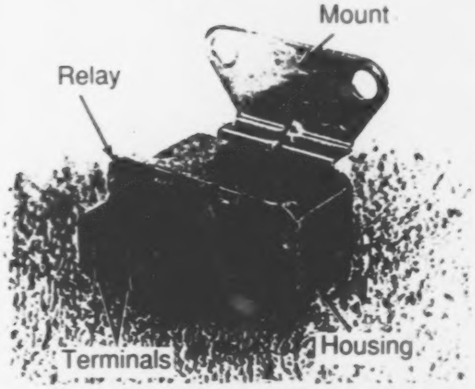
OBJECTIVE 3

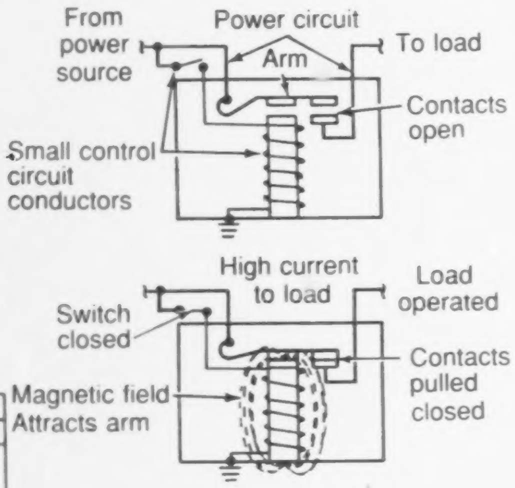
Describe the functions of starting system components.

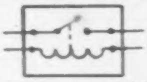
- Battery
  - Supplies starter motor with heavy current.
  - Supplies ignition switch with light current.
- Ignition Switch
  - Closes circuit
  - Provides energy to solenoid
  - Allows driver to control starting system

- Battery cables
  - — Conducts heavy current from battery to starter
- Relay (magnetic switch)

  May be used instead of or in conjunction with a solenoid.


Mount
Relay
Terminals
Housing


From power source
Power circuit
To load
Arm
Contacts open
Small control circuit conductors
High current to load
Load operated
Switch closed
Contacts pulled closed
Magnetic field Attracts arm

Relay	
Symbol	Letter designation
	REL

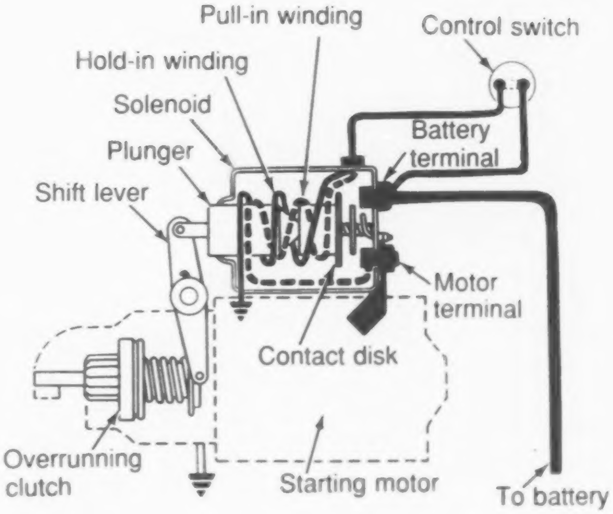
Used with permission of Ford Motor Company.

HOW A RELAY (MAGNETIC SWITCH) WORKS

A magnetic switch is composed of a hollow coil of wire circling a plunger. One end of the plunger acts as a contact to complete the circuit, the other end is attached to a spring. When current passes through the coil, a magnetic field is produced. The plunger is attracted by the magnetic force and contact is made. When contact is made, the starter turns the engine. The magnetic field is disrupted by opening the circuit at the starter switch, and the spring pulls the plunger from contact.

BEST COPY AVAILABLE

- Solenoid


Pull-in winding
Control switch
Hold-in winding
Solenoid
Battery terminal
Plunger
Shift lever
Motor terminal
Contact disk
Overrunning clutch
Starting motor
To battery

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— Shifts starting motor pinion and flywheel ring gear into engaged positions.

— May be used instead of a relay (magnetic switch).

NOTE: Most systems use a solenoid. Solenoids can be included in the starter casing or mounted alongside it.

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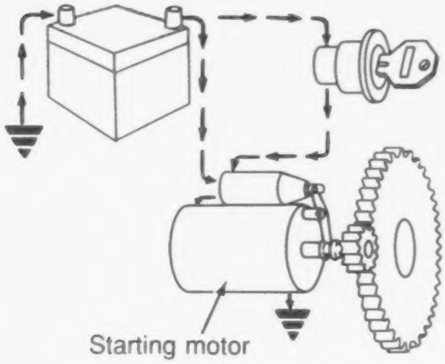
HOW A SOLENOID WORKS

A solenoid is made of two coils of wire, wound in the same direction, wrapped around a plunger. One end of the plunger acts as a contact to complete the circuit. The outer coil, called the hold-in winding, is made of fine wire and is connected to ground. The inner coil, called the pull-in winding, is made of heavier wire and is connected to the motor terminal of the solenoid and to ground (through the motor). The coils have an equal number of loops. When the ignition switch is put in the "start" position, current flows through both coils. This creates a strong magnetic field, which attracts the plunger. As the plunger moves, the drive pinion and flywheel gear are engaged. Final plunger movement completes the circuit by closing contact points within the solenoid. Current from the battery turns the engine. The strong cranking current shorts the heavy pull-in winding. The finer hold-in wiring continues to receive current.

When the engine begins to run and the starter switch is released from the start position, current flows in the opposite direction through the pull-in winding. Since amperage in the two windings is equal and they have the same number of turns, the magnetic fields generated oppose each other. The collapse of magnetic attraction allows a spring to pull the plunger back to its original position. As it slides back into position, current to the starter motor is cut off and the pinion is pulled out of position from the flywheel.

- Neutral safety switch
  - Prevents the car from starting when the transmission is in gear
  - May be found in several locations, depending upon maker and model. Consult a service manual for locations.
- Starting motor
  - Cranks the engine
  - Produces a large amount of energy (high horsepower) for a short period of time



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- Overrunning clutch
    - Locks when the gear turns one direction, freely spins the other direction (much like a bicycle gear which locks to pedal one direction and freewheels the other)
    - Permits the engine to run at speeds greater than those produced by the engine
    - Protects the starter from engine-speed damage
- Drive pinion gear (pinion drive gear)
    - Meshes with and drives the ring gear
    - Combined with the overrunning clutch, makes up the starter drive
    - Uses a flywheel/drive pinion ratio of 15:1-20:1

OBJECTIVE 4 **Distinguish among types of starters.**

NOTE: Starters are classified by the type of circuit found within the starting motor and by the starter drive mechanisms.

TYPE OF CIRCUIT

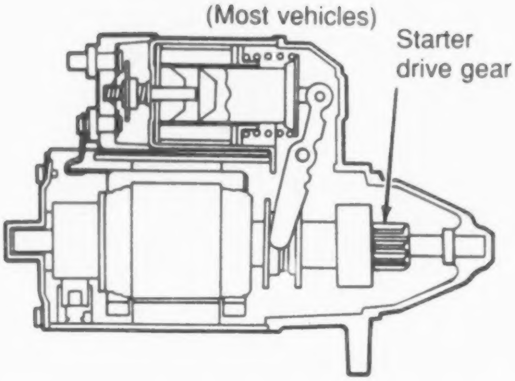
- **Series-wound**
    - Usually contains four pole shoes and four field coils

- Wound with flat, heavy copper wire
- Current traveling through series-wound wiring also travels through armature windings
- May allow excessive speed in the motor, causing armature windings to be thrown from their slots

- **Shunt-type**
  - Prevents starter motor from turning too rapidly. Current passes through a shunt coil and bypasses the armature
  - Wound with finer copper wire; wiring makes more turns than in series-wound
- **Compound wound**
  - Contains series-wound field coils and a shunt connected in parallel
- **Parallel wound**
  - Current divides
  - Starting motor provides more cranking power
- **Permanent magnet (PMGR)**
  - No field coil; permanent magnets are used instead
  - Smaller, lighter in weight
  - Used primarily on newer cars

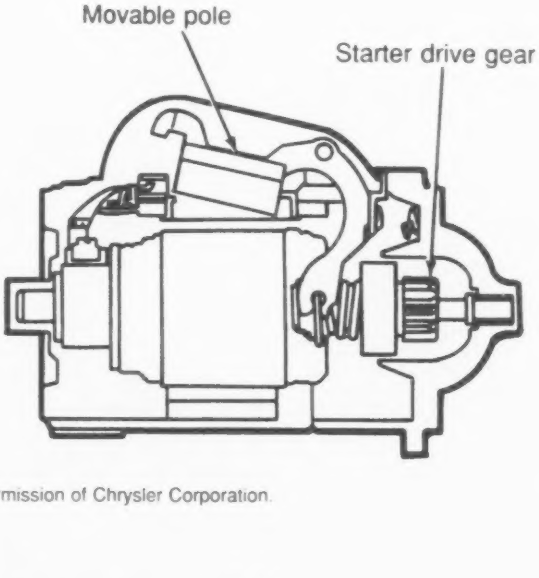
STARTER DRIVE MECHANISMS

- **Direct drive**
  - Most common type; used on most late model cars
  - Uses no gears to increase or decrease torque
  - Armature directly drives the flywheel through the pinion gear


(Most vehicles)
Starter drive gear

Used with permission of Chrysler Corporation.

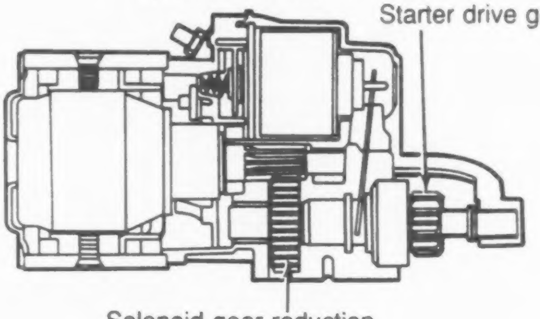
- **Moveable pole (positive engagement)**
  - Used in older model Fords
  - When the starter receives current, the magnetic field pulls the pole shoe downward. The yoke acts as a lever and pushes the pinion gear along the shaft until it engages with the flywheel.
  - Used in conjunction with a separate starter relay which provides current for the starter motor


Movable pole
Starter drive gear

Used with permission of Chrysler Corporation.

- **Solenoid gear reduction**
  - Includes a reduction gear assembly located between the overrunning clutch/pinion gear and the armature
  - The reduction gear reduces cranking speed and increases torque
  - Produces a high-pitched sound when starting

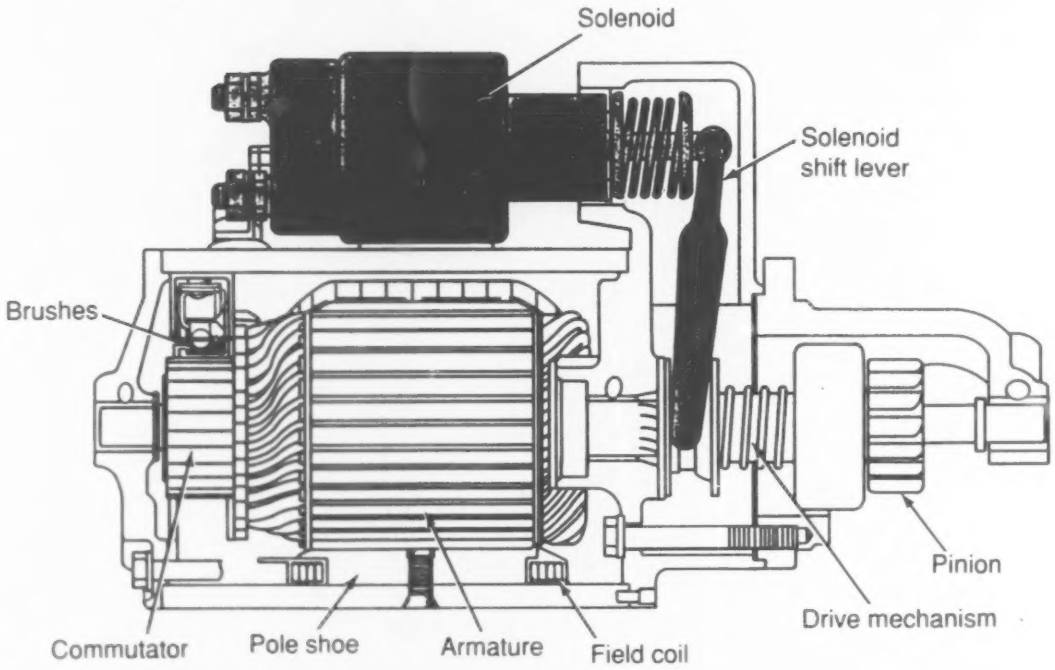
(Most vehicles)


Starter drive gear
Solenoid gear reduction

Used with permission of Chrysler Corporation.

OBJECTIVE 5 **Label parts of a starter.**

- Brushes
- Field coil
- Solenoid
- Solenoid shift lever
- Pinion gear
- Drive mechanism
- Pole shoe
- Commutator
- Armature


Solenoid
Solenoid shift lever
Brushes
Pinion
Drive mechanism
Commutator
Pole shoe
Armature
Field coil

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OBJECTIVE 6 **Describe how a starter operates.**

1. Current passes from the battery, through the ignition switch, in some cases, through the neutral safety switch, then finally to the solenoid.

   NOTE: Neutral safety switches are sometimes grounded.

2. The solenoid brings the pinion drive gear and the flywheel into mesh and sends current from the battery cable into the starter motor.

3. The current travels through the field coils, creating electromagnetic pole shoes.

4. Current also passes through the brushes and commutator to the armature. As the armature spins, the commutator ends contact with one loop and begins contact with another. As the succeeding coils become charged, they are repelled by the like- charged pole shoe. This causes the armature to spin, turning the armature shaft.

5. The spinning armature shaft turns the pinion drive gear, which turns the flywheel, which cranks the engine.

   NOTE: The starter draws on the battery for electrical energy, then converts it to mechanical energy to start the engine. While the car is in operation, the alternator converts some of the mechanical energy back into electrical energy and sends it to the battery. The battery converts the electrical energy into chemical energy for storage, then back into electrical energy when drawn on by the starter.

OBJECTIVE 7 **Distinguish between in-car and bench starter tests.**

- In-car tests
  - System quick-checks
  - Cranking circuit test
  - Load test

- Bench tests
  - Component tests
  - Armature test
  - Field coil test
  - Solenoid tests
  - Pull-in winding test
  - Hold-in winding test
  - Pinion clearance check
  - Brushes, springs, and holders check
  - Overrunning clutch check
  - Armature bushing check

STARTING SYSTEM TROUBLE SHOOTING

CONDITION	POSSIBLE CAUSE	CORRECTION
Starter Fails to Operate	Dead battery or bad connections between starter and battery	Check battery charge and all wires and connections to starter
	Ignition switch faulty or misadjusted	Adjust or replace ignition switch
	Open circuit between starter switch and ignition terminal on starter relay	Check and repair wires and connections as necessary
	Starter relay or starter defective	See Testing in STARTERS
	Open solenoid pull-in wire	See Testing in STARTERS
Starter Does Not Operate and Headlights Dim	Weak battery or dead battery cell	Charge or replace battery as necessary
	Loose or corroded battery connections	Check that battery connection are clean and tight
	Internal ground in starter windings	See Testing in STARTERS
	Grounded starter fields	See Testing in STARTERS
	Armature rubbing on pole shoes	See Overhaul in STARTERS
Starter Turns but Engine Does Not Rotate	Starter clutch slipping	See Overhaul in STARTERS
	Broken clutch housing	See Overhaul in STARTERS
	Pinion shaft rusted or dry	See Overhaul in STARTERS
	Engine basic timing incorrect	See Ignition Timing in TUNE-UP
	Broken teeth on engine flywheel	Replace flywheel and check for starter pinion gear damage
Starter Will Not Crank Engine	Faulty overrunning clutch	See Overhaul in STARTERS
	Broken clutch housing	See Overhaul in STARTERS
	Broken flywheel teeth	Replace flywheel and check for starter pinion gear damage
	Armature shaft sheared or reduction gear teeth stripped	See Overhaul in STARTERS
	Weak battery	Charge or replace battery as necessary
	Faulty solenoid	See On Vehicle Tests in STARTERS
	Poor grounds	Check all ground connections for tight and clean connections
	Ignition switch faulty or misadjusted	Adjust or replace ignition switch as necessary
Starter Cranks Engine Slowly	Battery weak or defective	Charge or replace battery as necessary
	Engine overheated	See ENGINE COOLING SYSTEMS
	Engine oil too heavy	Check that proper viscosity oil is used
	Poor battery-to-starter connections	Check that all connections between battery and starter are clean and tight
	Current draw too low or too high	See Bench Tests in STARTERS
	Bent armature, loose pole shoe screws or worn bearings	See Overhaul in STARTERS
	Burned solenoid contacts	Replace solenoid
	Faulty starter	Replace starter
Starter Engages Engine Only Momentarily	Engine timing too far advanced	See Ignition Timing in TUNE-UP
	Overrunning clutch not operating	Replace overrunning clutch. See Overhaul in STARTERS
	Broken starter clutch housing	See Overhaul in STARTERS
	Broken teeth on engine flywheel	Replace flywheel and check starter pinion gear for damage
	Weak drive assembly thrust spring	See Overhaul in STARTERS
	Weak hold-in coil	See Bench Tests in STARTERS

STARTING SYSTEM TROUBLE SHOOTING (Cont.)

CONDITION	POSSIBLE CAUSE	CORRECTION
Starter Drive Will Not Engage	Defective point assembly	See Testing in STARTERS
	Poor point assembly ground	See Testing in STARTERS
	Defective pull-in coil	Replace starter solenoid
Starter Relay Does Not Close	Dead battery	Charge or replace battery as necessary
	Faulty wiring	Check all wiring and connections leading to relay
	Neutral safety switch faulty	Replace neutral safety switch
	Starter relay faulty	Replace starter relay
Starter Drive Will Not Disengage	Starter motor loose on mountings	Tighten starter attaching bolts
	Worn drive end bushing	See Overhaul in STARTERS
	Damaged engine flywheel teeth	Replace flywheel and check starter pinion gear for damage
	Drive yolk return spring broken or missing	Replace return spring
	Faulty ignition switch	Replace ignition switch
	Solenoid contact switch plunger stuck	Replace starter solenoid
	Faulty starter relay	Replace starter relay
	Insufficient clearance between winding leads to solenoid terminal and main contact in solenoid	Replace starter solenoid
	Starter clutch not disengaging	Replace starter clutch
	Ignition starter switch contacts sticking	Replace ignition switch
Starter Relay Operates but Solenoid Does Not	Faulty solenoid switch, switch connections or switch wiring	Check all wiring between relay and solenoid or replace relay or solenoid as necessary
	Broken lead or loose soldered connections	Repair wire or wire connections as necessary
Solenoid Plunger Vibrates When Switch is Engaged	Weak battery	Charge or replace battery as necessary
	Solenoid contacts corroded	Clean contacts or replace solenoid
	Faulty wiring	Check all wiring leading to solenoid
	Broken connections inside switch cover	Repair connections or replace solenoid
	Open hold-in wire	Replace solenoid
Low Current Draw	Worn brushes or weak brush springs	Replace brushes or brush springs as necessary
High Pitched Whine During Cranking Before Engine Fires but Engine Fires and Cranks Normally	Distance too great between starter pinion and flywheel	Align starter or check that correct starter and flywheel are being used
High Pitched Whine After Engine Fires With Key Released. Engine Fires and Cranks Normally	Distance too small between starter pinion and flywheel. Flywheel runout contributes to the intermittent nature	Align starter or check that correct starter and flywheel are being used

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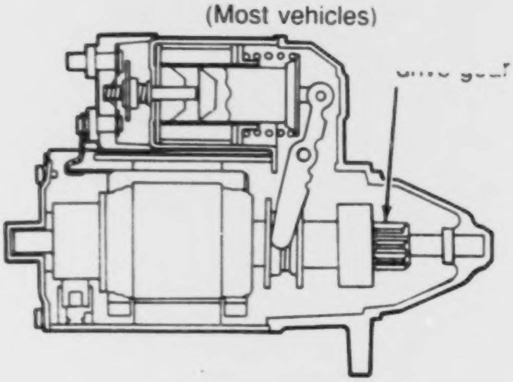
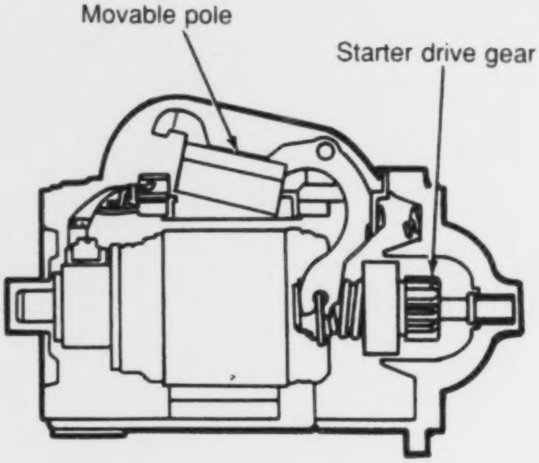
COMPARISON OF STARTER TYPES

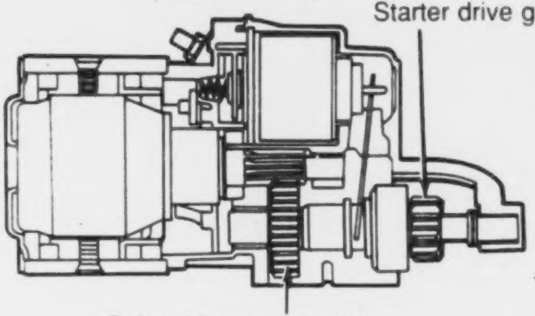

(Most vehicles)


Movable pole
Starter drive gear

Used with permission of Chrysler Corporation.

COMPARISON OF STARTER TYPES
(Continued)

(Most vehicles)


Starter drive gear
Solenoid gear reduction

Used with permission of Chrysler Corporation

ACTIVITY SHEET 1

STARTING SYSTEM

III

NAME ______________________________ SCORE ________

LOCATE STARTERS AND STARTING SYSTEM COMPONENTS

Choose the service manuals for three different cars. In each manual, locate the starter and other starting system components.

1. List components and component types.

____

____

____

____

____

____

2. What components are in all three cars?

____

____

____

3. What components are found in some, but not all, the cars?

____

4. How many use a neutral safety switch?

____

Manuals used:

Year	Make	Model

ASSIGNMENT SHEET 1

STARTING SYSTEM

III

NAME ________________________________ SCORE ________

OBJECTIVE 8

Diagnose starting system problems.

INTRODUCTION

As an electronics specialist, or in any service position, you will be called upon to determine the most likely cause of starting system problems. By listening to the customer's description of the problem and observing the system's performance, you can identify the most probable causes of the trouble. By narrowing the possibilities, tests and repair time can be kept to a minimum.

DIRECTIONS

1. Use the troubleshooting chart in Supplement 1 OR locate the troubleshooting manual of the vehicle chosen. Turn to the starting systems section of the manual. Locate starting system troubleshooting information.

2. Describe the tests and other procedures indicated in the circumstances listed below.

   NOTE: Remember that the starter is only one part of an electrical circuit. Starting problems do not mean starter trouble. Any diagnosis of a starting system problem must begin with checking battery cables, the battery itself, and the circuit for continuity.

Case #1

The owner tells you that the starter won't turn over. When the key is turned in the ignition, a clicking noise is heard.

____

____

____

____

____

Case #2

Nothing happens when the switch is turned.

____

____

____

____

____

Case #3

Slow cranking.

____

____

____

____

____

ASSIGNMENT SHEET 1

Case #1

Overhaul starter.

Replace flywheel and check for pinion drive gear damage.

Charge or replace battery.

On-vehicle tests (amp draw, resistance, others according to model and make).

Check all connections.

Adjust or replace ignition switch.

Check solenoid and relay contacts.

Case #2

Check battery charge.

Check connections and wires to starter.

Adjust or replace ignition switch.

Check circuit for continuity (opens).

Test starter relay (according to service manual).

Load test battery.

Case #3

Starter draw test.

Battery check.

Check cables for resistance.

Check for mechanical resistance in the engine.

Overhaul starter.

JOB SHEET 1

STARTING SYSTEM

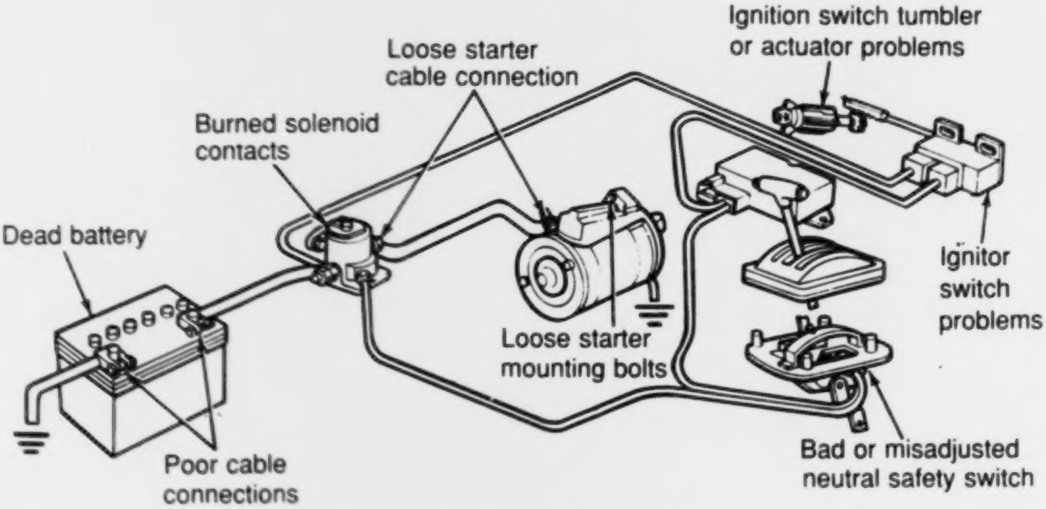
III

OBJECTIVE 9a

Test starting system.

TOOLS AND EQUIPMENT

- Service manual
- Hydrometer (non-maintenance-free batteries)
- Battery terminal cleaning solution and brush
- Terminal
- Multimeter
- Ammeter
- Voltmeter
- Carbon pile resistor
- Jumper wire
- Tachometer
- Safety glasses
- Fender covers
- Seat covers
- Floor mat


Ignition switch tumbler or actuator problems
Loose starter cable connection
Burned solenoid contacts
Dead battery
Ignitor switch problems
Loose starter mounting bolts
Poor cable connections
Bad or misadjusted neutral safety switch

Used with permission of Chrysler Corporation.

PROCEDURE

- **System Quick Tests**

1. Test the battery.
2. Clean and tighten system connections and grounds.

   NOTE: Pay particular attention to the circuit between the battery and solenoid/starter motor.

3. Turn on the headlights and start the engine.
4.

If this happens	Check for this
No lights or cranking	Open fusible link
Lights bright; no cranking or sound from solenoid	Open in the solenoid circuit
Lights bright; solenoid clicks; no cranking	Open in the motor circuit
Lights dim; no cranking assembly	Jammed drive
Lights dim; slow cranking	Pitted contacts in solenoid; worn brushes; pitted or shorted commutator; engine problem

PROCEDURE

- **Cranking circuit test - reveals excessive resistance**
- **Starter draw test**

NOTE: The engine temperature should be as close to normal operating temperature as possible for cranking circuit test results to be conclusive.

♦ WARNING ♦

The service manual should be consulted before performing any test. Follow the procedures listed in the service manual. The description below is a basic outline of the procedure and should not be used in place of a service manual.

1. Disable the ignition system according to the service manual procedures.

   NOTE: It is important that you follow procedures to avoid damaging the vehicle.

2. Connect the negative lead of a voltmeter to the solenoid starter terminal; the positive lead to the positive terminal of the battery.

3. Select the low-voltage scale on the meter.

4. Crank the engine.

5. Note the voltage reading. This is the voltage drop while cranking and should not exceed 0.5 volts.

6. Move the positive lead from the battery terminal to the solenoid battery terminal.

7. Crank the engine.

8. Note the voltage reading. This time it should not exceed 0.3 volts.

9. Move the meter's negative lead from the solenoid starter terminal to the solenoid battery terminal.

10. Move the meter's positive lead from the solenoid battery terminal to the battery positive terminal.

11. Crank the engine.

12. Note the voltage reading. It should not exceed 0.2 volts.

13. Move the meter's negative lead from the solenoid battery terminal to the battery negative terminal.

14. Move the meter's positive lead from the battery positive terminal to the engine block or other ground.

15. Crank the engine.

16. Note the voltage reading. It should not exceed 0.1 volts.

OBJECTIVE 9b

Remove starter.

TOOLS AND EQUIPMENT

- Service manual
- Safety glasses
- Fender covers
- Shims

PROCEDURE

Removal

♦ WARNING ♦

The service manual should be consulted before performing any procedure. Follow the procedures listed in the service manual. The description below is a basic outline of the procedure and should not be used in place of a service manual.

1. Disconnect the battery, using proper procedures.

2. Unbolt the solenoid wires, battery cable, and any braces on the motor.

3. Unscrew the bolts holding the starting motor.

   NOTE: Hold the starting motor while unscrewing the supporting bolts. Damage will occur if it falls.

4. Check the flywheel and pinion drive gear for shims. If any shims are present, they must be returned to the same place during reassembly to insure proper performance.

5. Lift starter out of the car.

6. Inspect the flywheel and pinion drive teeth for excessive wear.

PROCEDURE

- **No-load test** - reveals how fast the armature will revolve and the amount of current draw

  ♦ WARNING ♦

  The service manual should be consulted before performing any test. Follow the procedures listed in the service manual. The description below is a basic outline of the procedure and should not be used in place of a service manual.

1. Remove starter motor. Place it in a bench vise.

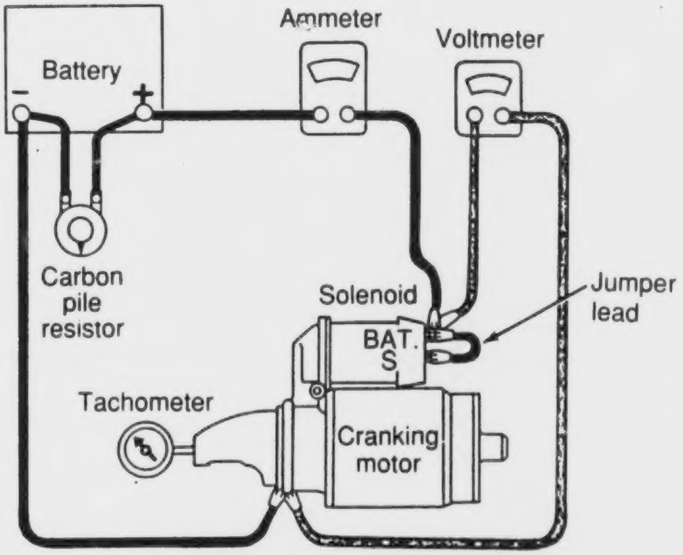
2. Connect starting motor to fully-charged battery.

3. Place an ammeter between the battery and starting motor.

4. Connect a voltmeter to the starting motor terminal and the other lead to the starting motor housing.

5. Connect a carbon pile resistor across the battery.

6. Place a jumper wire between the battery terminal and solenoid "S" terminal.


Battery
−
+
Ammeter
Voltmeter
Carbon pile resistor
Solenoid
BAT.
S
Jumper lead
Tachometer
Cranking motor

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7. Attach a tachometer to the end of the armature to measure armature speed.

8. Current will flow to the starting motor. Vary the resistor until the voltmeter reads the voltage specified in the service manual.

9. When the specified voltage is achieved, read the ammeter for current draw and the tachometer for armature speed. Compare these readings with service manual specs and follow suggested repair procedures.
10. Have your instructor check your work.
11. Put away tools and materials and clean the work area.

PROCEDURE

Reinstallation

1. Place the starter in position and hold it there.
2. Replace shims, if required.
3. Tighten bolts.
4. Connect solenoid wires.
5. Replace brackets and shields.
6. Reconnect battery cables and battery.
7. Check drive pinion to flywheel teeth clearance against service manual specs.
8. Crank the engine several times to check performance.
9. Have your instructor check your work.
10. Put away tools and materials and clean the work area.

JOB SHEET 3

STARTING SYSTEM

III

OBJECTIVE 9c **Disassemble and bench test starter.**

TOOLS AND EQUIPMENT

- Service manual
- Wrenches
- Ratchet sockets, swivel joints, and extensions
- Plastic hammer
- Compressed air for cleaning parts
- Clean, dry cloth
- Caliper
- Ohmmeter
- Soldering gun
- Rosin core solder
- Clamps
- Battery
- Jumper cables
- Snap ring pliers
- Safety glasses
- Fender covers

PROCEDURE

♦ WARNING ♦

The service manual should be consulted before performing any procedure. Follow the procedures listed in the service manual. The description below is a basic outline of the procedure and should not be used in place of a service manual.

NOTE: As you disassemble the starter, place the parts in an organized manner on your bench. This will help you reassemble more easily, even if you forget where things were originally.

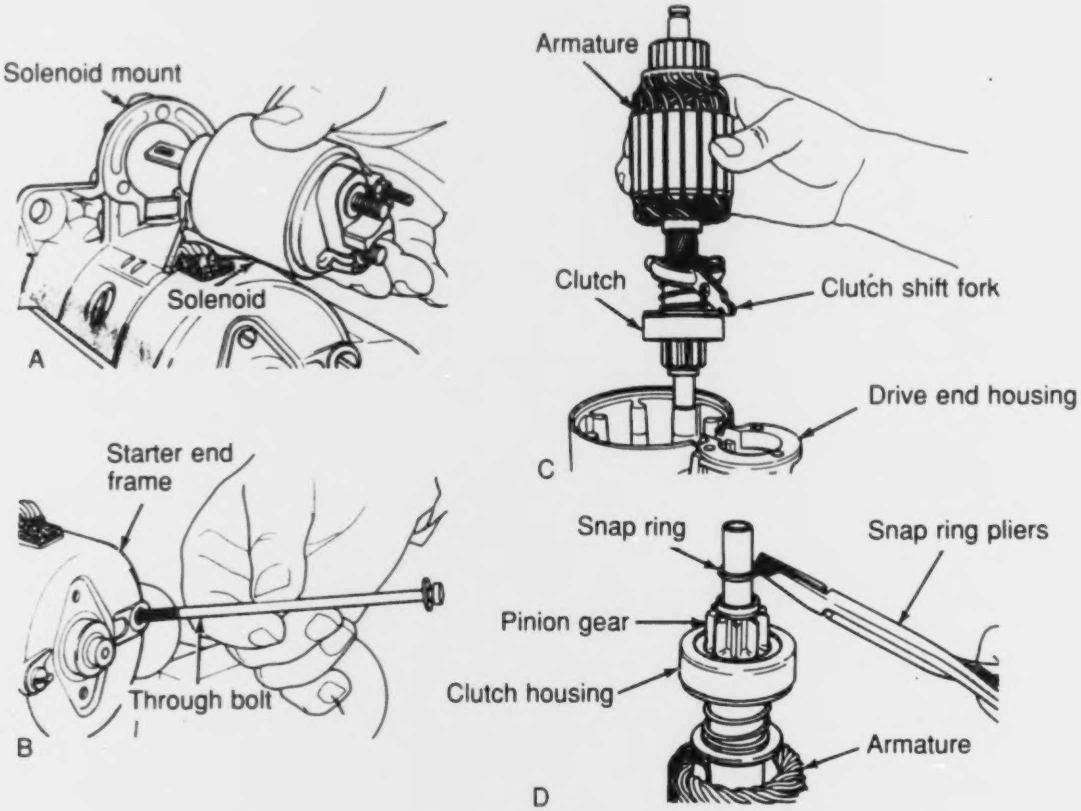
1. Remove fasteners holding in the solenoid.
2. Lift out the solenoid, being careful not to lose the plunger spring.

   NOTE: Rotating the solenoid slightly may help.
3. Mark the end frames.
4. Remove through-bolts.
5. Use a plastic hammer to tap off the end frames.

6. Remove end frames.

7. Slide out armature.

8. Locate and remove the C-clip holding the pinion drive gear on the shaft of the armature.


Solenoid mount
Solenoid
A
Starter end frame
Through bolt
B
Armature
Clutch
Clutch shift fork
Drive end housing
C
Snap ring
Snap ring pliers
Pinion gear
Clutch housing
Armature
D

Used with permission of Chrysler Corporation.

9. Remove the pinion drive gear.

10. Blow all the parts clean with compressed air.

11. Wipe the armature, field windings, brushes, and overrunning clutch clean. Use a clean, dry cloth. Do not use solvent or water.

12. Visually check all parts for wear.

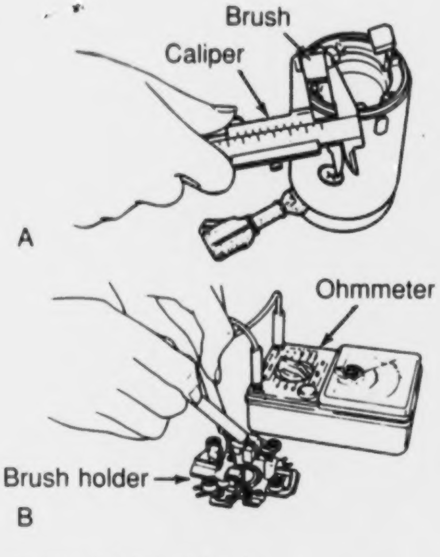
    NOTE: Worn starter bushings is one of the most common problems. If they are worn, the armature can rub on the field pole shoes, causing serious starter damage. Also check the pole shoes for signs of rubbing, the commutator for pitted or worn spots.

13. Check the brushes. Find manufacturer specifications and procedures.

    a. Measure the brushes with the calipers to see that they are not excessively worn.

    b. Use the ohmmeter to check the brushes for shorts.

    c. If they must be replaced, use a soldering gun and rosin core solder.



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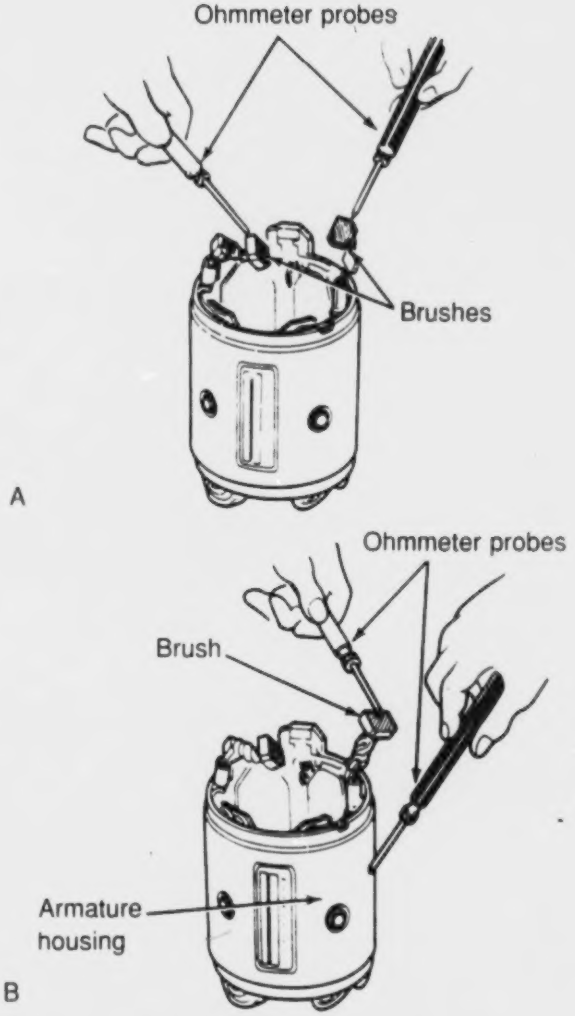

Ohmmeter probes
Brushes
A
Ohmmeter probes
Brush
Armature housing
B

Used with permission of American Honda Company.

14. Test the armature.

    NOTE: This procedure will be part of Job Sheet 4. Complete it at this time, then return to Job Sheet 3.

15. Check the field coils.

    a. Visually check for signs of damage.

    b. Test for open field coils with an ohmmeter.

   c. Consult the service manual for proper procedure. Test for grounded field coils by touching the ohmmeter probes to the brushes (low ohms should register) and to one brush and to a ground (high ohms should register).

16. Check the overrunning clutch and pinion drive gear.
    a. Check the overrunning clutch by turning it. It should turn freely one direction but lock the other.
    b. The pinion drive gear should be replaced every time the starter is disassembled.

17. Reassemble the starter. Follow disassembly instructions in reverse.

18. Lubricate the pinion gear splines, armature shaft bushings, and other parts as recommended in the service manual.

CAUTION

Do not overlubricate.

PROCEDURE

No-load test

1. Clamp the starter to a work bench.
2. Connect the starter to a battery with jumper cables. Connect the positive cable first.
3. Check for proper motor speed and pinion drive gear position, referring to the service manual for specs.
4. Measure the pinion gear clearance (the distance between the drive end frame and the drive pinion while the pinion is engaged) and adjust if needed to meet manufacturer's specs.
5. Reinstall the solenoid and starter.
6. Have your instructor check your work.
7. Put away tools and materials and clean the work area.

OBJECTIVE 9d

Test armature

TOOLS AND EQUIPMENT

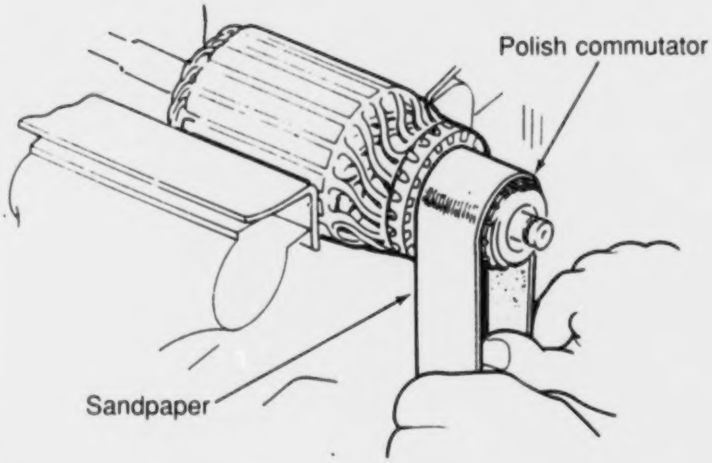
- Service manual
- Safety glasses
- Growler (armature tester)
- Thin piece of metal or hacksaw blade
- Ohmmeter

PROCEDURE

1. Check the commutator for wear or burn marks.
2. Make sure the shaft is straight, not bent.
3. Check the ends of the shaft for wear.
4. Mount the armature on a growler and test according to growler instructions.

   NOTE: This procedure will include holding a thin metal strip or hacksaw blade next to the armature while it turns on the growler. If windings in the armature have shorted, the metal piece will vibrate as it turns.

5. Check the armature for continuity by touching ohmmeter probes to either side of each commutator segment. If the ohmmeter shows universal resistance, the armature must be replaced.
6. Check the armature for grounds. Touch one ohmmeter probe to the armature core, the other to the commutator segments, one at a time. Then touch one probe to the armature shaft, the other to the commutator segments. If resistance is low the armature must be replaced.
7. Sand the commutator with very fine sandpaper as shown below.


Polish commutator
Sandpaper

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8. Return to Job Sheet 3.

PRACTICAL TEST 1

STARTING SYSTEM

III

JOB SHEET 1

Test the starting system.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
System quick tests		
1. Tested the battery.	_____	_____
2. Cleaned and tightened system connections and grounds.	_____	_____
3. Turned on headlights, cranked engine, and made appropriate diagnosis according to quick test notes.	_____	_____
Cranking circuit test/Starter draw test		
1. Disabled the ignition system, according to the service manual procedures.	_____	_____
2. Connected the negative lead of a voltmeter to the solenoid starter terminal; the positive lead to the positive terminal of the battery and cranked the engine and noted the voltage reading.	_____	_____

	YES	NO
3. Moved the positive lead from the battery terminal to the solenoid battery terminal, cranked the engine and noted the voltage reading.	____	____
4. Moved the meter's negative lead from the solenoid starter terminal to the solenoid battery terminal, the meter's positive lead from the solenoid battery terminal to the battery positive terminal, cranked the engine, and noted the voltage reading.	____	____
5. Moved the meter's positive lead from the battery positive terminal to the engine block or other ground, cranked the engine, and noted the voltage reading.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Used service manual correctly	4	3	2	1
Tested battery and circuit thoroughly	4	3	2	1
Made all test connections correctly	4	3	2	1
Read all meters correctly	4	3	2	1
Adjusted to specified voltage	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 2

STARTING SYSTEM

JOB SHEET 2

Remove and replace starter.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
Removal		
1. Disconnected the battery.	_____	_____
2. Unbolted the solenoid wires, battery cable, and any braces on the motor.	_____	_____
3. Unscrewed the bolts holding the starting motor.	_____	_____
4. Checked the flywheel and pinion drive gear for shims.	_____	_____
5. Lifted the starter out of the car.	_____	_____
6. Inspected the flywheel and pinion drive teeth for excessive wear.	_____	_____
No-load test		
1. Connected starting motor to fully-charged battery.	_____	_____

	YES	NO
2. Placed an ammeter between the battery and starting motor.	_____	_____
3. Connected a voltmeter to the starting motor terminal and the other lead to the starting motor housing.	_____	_____
4. Connected a carbon pile resistor across the battery.	_____	_____
5. Placed a jumper wire between the battery terminal and solenoid "S" terminal.	_____	_____
6. Attached a tachometer to the end of the armature to measure armature speed.	_____	_____
7. Varied the resistor until the voltmeter read the voltage specified in the service manual.	_____	_____
8. Read the ammeter for current draw and the tachometer for armature speed.	_____	_____
9. Compared those readings with service manual specs and followed suggested repair procedures.	_____	_____
10. Used proper tools correctly.	_____	_____
11. Performed steps in a timely manner.	_____	_____
12. Practiced safety rules throughout procedure.	_____	_____
13. Provided satisfactory responses to questions asked.	_____	_____
14. Put away tools and cleaned work area.	_____	_____

Reinstallation

	YES	NO
1. Placed the starter in position and held it there.	_____	_____

		YES	NO
2.	Replaced shims.	____	____
3.	Connected solenoid wires.	____	____
4.	Tightened bolts.	____	____
5.	Replaced brackets and shields.	____	____
6.	Reconnected battery cables and battery.	____	____
7.	Cranked the engine several times to check performance.	____	____
8.	Used proper tools correctly.	____	____
9.	Performed steps in a timely manner.	____	____
10.	Practiced safety rules throughout procedure.	____	____
11.	Provided satisfactory responses to questions asked.	____	____
12.	Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Made all necessary preparations for removal	4	3	2	1
Held starter in place then lifted it without incident	4	3	2	1
Replaced and reconnected starter without incident	4	3	2	1
Replaced shims and reconnected cables properly	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3

STARTING SYSTEM

JOB SHEET 3

Disassemble and bench-test starter.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Removed the solenoid.	_____	_____
2. Removed through-bolts and end frames; slid out armature.	_____	_____
3. Removed the pinion drive gear.	_____	_____
4. Visually checked starter bushings, commutator, and pole shoes for wear.	_____	_____
5. Checked the brushes.		
a. Measured the brushes with the calipers.	_____	_____
b. Used the ohmmeter to check the brushes for shorts.	_____	_____
6. Checked the field coils.		
a. Visually checked for signs of damage.	_____	_____
b. Tested for open field coils.	_____	_____

	YES	NO
c. Tested for grounded field coils with an ohmmeter.	____	____
7. Checked the overrunning clutch.	____	____
8. Replaced/Checked the pinion drive gear.	____	____
9. Lubricated the pinion gear splines, armature shaft bushings, and other parts as recommended in the service manual.	____	____
10. Connected the starter to a battery with jumper cables and tested performance.	____	____
11. Checked for proper motor speed and pinion drive gear position, referring to the service manual for specs.	____	____
12. Measured the pinion gear clearance and adjusted as necessary.	____	____
13. Reinstalled the starter.	____	____
14. Used proper tools correctly.	____	____
15. Performed steps in a timely manner.	____	____
16. Practiced safety rules throughout procedure.	____	____
17. Provided satisfactory responses to questions asked.	____	____
18. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Removed solenoid and starter	4	3	2	1
Disassembled starter in an organized manner	4	3	2	1
Cleaned parts thoroughly	4	3	2	1
Visually checked all parts thoroughly	4	3	2	1
Measured brushes and tested for shorts thoroughly and accurately	4	3	2	1
Reassembled starter correctly	4	3	2	1
Brought motor speed and pinion drive clearance to specs	4	3	2	1
Reinstalled solenoid and starter quickly and correctly	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

STARTING SYSTEM

JOB SHEET 4

Test armature.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Removed and disassembled starter.	____	____
2. Visually checked the armature for damage or wear.	____	____
3. Mounted the armature on a growler and tested according to growler instructions.	____	____
4. Checked the armature for continuity.	____	____
5. Checked the armature for grounds.	____	____
6. Sanded the commutator.	____	____
7. Used proper tools correctly.	____	____
8. Performed steps in a timely manner.	____	____
9. Practiced safety rules throughout procedure.	____	____
10. Provided satisfactory responses to questions asked.	____	____

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Removed and disassembled starter quickly and thoroughly	4	3	2	1
Tested armature on growler accurately	4	3	2	1
Sanded commutator correctly and carefully	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

STARTING SYSTEM

III

NAME ______________________________ SCORE ________

OBJECTIVE 1

Match terms associated with servicing starting systems to their correct definitions. Write the correct letters in the blanks.

_____1. A series of wire loops surrounded by electromagnets which produces a strong electrical current

_____2. Magnets in the starter field frame

_____3. Stationary conductors which transmit current to the commutator

_____4. Copper pieces connected to each armature loop which transmit and cut off current from the brushes to the armature, providing the alternating polarity needed to turn the armature

_____5. Turning power

_____6. Coils of wire around the pole shoes. When current passes through the field coils, an electromagnet is produced

_____7. An electromagnetic component that converts electrical power to mechanical action

_____8. An electromagnetic switch that completes a circuit

a. Armature

b. Brushes

c. Bushings

d. Commutator

e. Field coils

f. Flywheel

g. Growler

h. Pole shoes

i. Relay

j. Solenoid

k. Speed

l. Torque

OBJECTIVE 2 Draw a diagram of the starting system.

OBJECTIVE 3 **Describe the function of starting system components.**

1. Battery ______________________________

____

____

____

2. Ignition Switch ______________________________

____

____

____

3. Battery cables ______________________________

____

4. Magnetic switch (relay) ______________________________

____

____

5. Solenoid ______________________________

____

____

____

6. Starting motor ______________________________

____

____

7. Overrunning clutch ______________________________

8. Drive pinion gear (pinion drive gear) ______________________________

9. Neutral safety switch ______________________________

OBJECTIVE 4 **Distinguish among types of starters.**

TYPE OF CIRCUIT

Write "SW" in the blank before characteristics of a series-wound starter, "ST" before characteristics of a shunt-type starter, "C" before characteristics of a compound-wound starter, "P" before characteristics of a parallel-wound starter, and "PM" before characteristics of permanent magnetic starters.

______1. Usually contains four pole shoes and four field coils

______2. No field coil; permanent magnets are used instead

______3. Prevents starter motor from turning too rapidly. Current passes through a shunt coil and bypasses the armature

______4. Used primarily on newer cars

______5. Contains series-wound field coils and a shunt connected in parallel

______6. Current divides

______7. Wound with flat, heavy copper wire

______8. Wound with finer copper wire; wiring makes more turns than in series-wound

______9. Starting motor provides more cranking power

______10. Current traveling through wiring also travels through armature windings

______11. Smaller, lighter in weight

______12. May allow excessive speed in the motor, causing armature windings to be thrown from their slots

TYPES OF STARTER DRIVE MECHANISMS

Write "D" before direct drive starter characteristics, "P" before moveable pole characteristics, and "S" before solenoid gear reduction characteristics.

______1. Most common type; used on most General Motors and foreign models and late-model Fords

______2. When the starter receives current, the magnetic field pulls the pole shoe downward. The yoke acts as a lever and pushes the pinion gear along the shaft until it engages with the flywheel

______3. A gear reduces cranking speed and increases torque

______4. Used in larger Chrysler and some General Motors models. It is usually used on larger engines requiring more starting power

______5. Used in older model Fords

______6. Uses no gears to increase or decrease torque

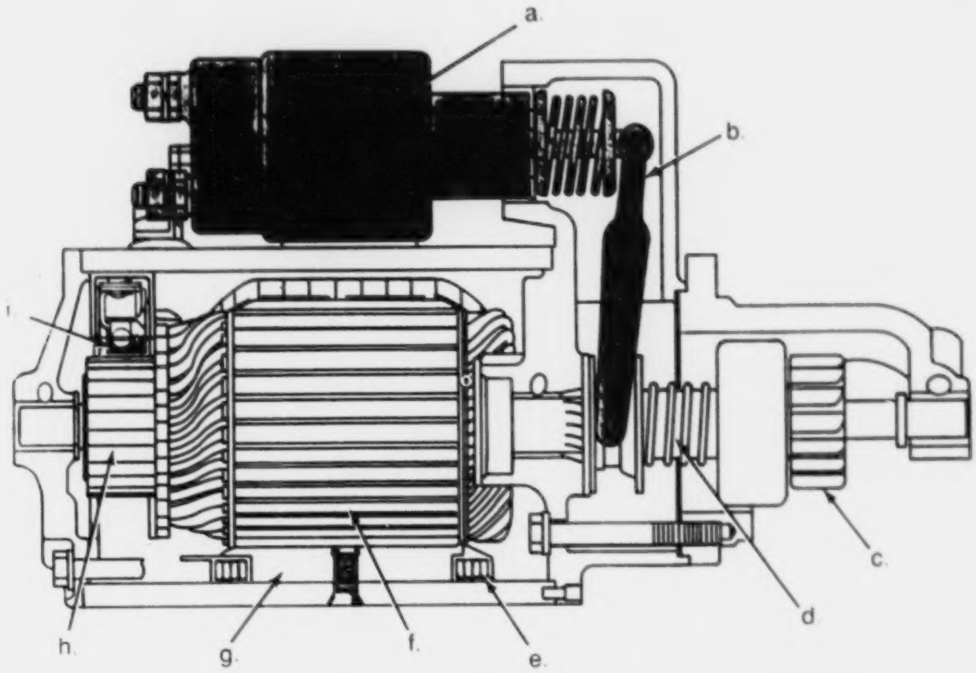
______7. Armature directly drives the flywheel through the pinion gear

______8. Used in conjunction with a separate starter relay which provides current for the starter motor

_______9. Includes a reduction gear assembly located between the overrunning clutch/pinion gear and the armature

______10. Produces a high-pitched sound when starting

OBJECTIVE 5 **Label parts of a starter.**



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

OBJECTIVE 6 **Describe how a starter operates.**

____

____

____

____

____

____

____

____

____

____

OBJECTIVE 7 **Distinguish between in-car and bench starter tests.**

Write "I" in the blank before in-car tests and "B" in the blank before bench tests.

______1. Pull-in Winding test

______2. Component tests

______3. System quick-checks

______4. Armature test

______5. Hold-in Winding test

______6. Cranking circuit test

______7. Field Coil test

______8. Load test

______9. Solenoid tests

______10. Pinion Clearance check

_____11. Brushes, springs, and holders check

_____12. Overrunning clutch check

_____13. Armature bushing check

NOTICE The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.

OBJECTIVE 8	**Diagnose starting system problems.**	SCORE _____
OBJECTIVE 9a	**Test the starting system.**	RATING _____
OBJECTIVE 9b	**Remove and replace a starter.**	RATING _____
OBJECTIVE 9c	**Disassemble and bench test a starter.**	RATING _____
OBJECTIVE 9d	**Test armature.**	RATING _____

WRITTEN TEST ANSWERS

STARTING SYSTEM

OBJECTIVE 1

1. a
2. f
3. b
4. d
5. h
6. e

OBJECTIVE 2

Drawing should include the battery, ignition switch, battery cables, a relay, solenoid, and overrunning clutch with appropriate leads. Use the illustraton in the Information Sheet, Objective 2, as an example.

OBJECTIVE 3

Answers should include the following:

- Battery
  - Supplies starter motor and ignition switch with current
  - Receives energy from ground (chassis)
- Ignition Switch
  - Closes circuit
  - Provides energy to solenoid
  - Allows driver to control starting system
- Battery cables
  - Conducts heavy current from battery to starter
- Relay (magnetic switch)
  - Completes circuit between starter and engine
  - May be used instead of a solenoid
- Solenoid
  - Completes circuit between starter and engine
  - Shifts starting motor pinion and flywheel ring gear into engaged positions
  - May be used instead of a magnetic switch (relay)

- Starting motor
  - Cranks the engine
  - Produces a large amount of energy (high horsepower) for a short period of time
- Overrunning clutch
  - Locks when the gear turns one direction, freely spins the other direction (much like a bicycle gear which locks to pedal one direction and freewheels the other)
  - Permits the engine to run at speeds greater than those produced by the starter
  - Protects the starter from engine-speed damage
- Drive pinion gear (pinion drive gear)
  - Meshes with and drives the ring gear
  - Combined with the overrunning clutch, makes up the starter drive

OBJECTIVE 4

1. SW
2. PM
3. ST
4. PM
5. C
6. P
7. SW
8. ST
9. P
10. SW
11. PM
12. SW

1. D
2. P
3. S
4. S
5. P
6. D
7. D
8. P
9. S
10. S

OBJECTIVE 5

a. Solenoid
b. Solenoid shift lever
c. Pinion
d. Drive mechanism
e. Field gear coil
f. Armature
g. Pole shoe
h. Commutator
i. Brushes

OBJECTIVE 6

Description should include:

1. Current passes from the battery through ignition switch and battery to solenoid.

2. Solenoid brings pinion drive gear and flywheel into mesh and sends current to starter.
3. Current passes through field coils. Pole shoes become electromagnets.
4. Current passes through brushes and commutator to armature. Magnetic repulsion spins armature and armature shaft.
5. Shaft turns pinion drive gear, which turns flywheel, which cranks the engine.

OBJECTIVE 7

1. B
2. B
3. I
4. B
5. B
6. I
7. B
8. I
9. B
10. B
11. B
12. B
13. B

OBJECTIVE 8 Refer to Answers to Assignment Sheet 1.

OBJECTIVE 9 Refer to Practical Tests for Job Sheets 1 - 4.

OBJECTIVE SHEET

CHARGING SYSTEM

IV

INTRODUCTION

Electrical and electronic equipment must have electric current to operate. The battery provides some current, but would quickly discharge if a charging system were not in place. Like many other systems, the charging system has undergone great change in recent years. Alternators and regulators may be mechanical or electronic. The wide range of components used today make understanding the basic functions of the system important for any service technician.

UNIT OBJECTIVE

After completing this unit the student should be able to identify and discuss the purpose, components, tests and operations of voltage regulators and alternators; and should be able to perform standard tests, and remove, replace, and service alternators. The student will demonstrate these competencies by completing an assignment sheet, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms related to servicing the charging system to their correct definitions.
2. Explain the purpose of the charging system.
3. List the functions of charging system components.
4. Name charging system tests according to their descriptions.
5. Discuss causes of undercharging.
6. Label electronic and electromechanical voltage regulators.
7. Select from a list true statements about the operation of a voltage regulator.
8. Label parts of an alternator.
9. Arrange in order statements about the operation of an alternator.
10. Diagnose charging system problems. (Assignment Sheet 1)

11. Demonstrate the ability to:

    a. Perform output test. (Job Sheet 1)

    b. Test the voltage regulator. (Job Sheet 2)

    c. Remove and replace an alternator. (Job Sheet 3)

    d. Service an alternator. (Job Sheet 4)

CHARGING SYSTEM

PREPARATION

- Review unit and plan presentation.
- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.
- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.
- Review teaching suggestions and plan classroom activities.
- Determine how you will schedule time for students to demonstrate competence in the required procedures.
- Order materials to supplement unit.
- Invite an electrical service specialist to speak to the class.

  NOTE: Supply guest speakers with the Objective Sheet, Information Sheet and any other components you want them to cover.

DELIVERY

Objective 1 Match terms related to servicing the charging system to their correct definitions.

- Review terms and add other terms students are not familiar with to the list.

Objective 2 Explain the purpose of the charging system.

- Have students list the effects of no charging system. Include driver comfort (no power windows or radio), diagnostic (CPU, etc.), and performance (electronic ignition, starter, etc.) systems affected.
- Link the purpose of the charging system with related systems.

Objective 3 List the functions of charging system components.

- Have students use parts catalogs or repair manuals to compare components between makes, and on current models to models 5 and 10 years ago.

Objective 4 Name charging system tests according to their descriptions.

Objective 5 Discuss causes of undercharging.

- Make it clear to students that tests vary greatly between makes and models and that all tests should be performed according to service manual instructions.
- Have students compare testing procedures between several makes and models.
- Have students use diagnostic equipment to test the charging system.
- Have students complete Assignment Sheet 1 and Job Sheet 1.

Objective 6 Label electronic and electromechanical voltage regulators.

Objective 7 Select from a list true statements about the operation of a voltage regulator.

- Have students look at and possibly disassemble a variety of voltage regulators, including electromechanical and electronic models.
- Have students use parts catalogs to compare regulators.
- Have students theorize what the effect of unregulated voltage might be.
- Have examples of various types of electromechanical and electronic regulators available for students.

- Have students compare manufacturer's recommended test procedures. Have them compare testing for electromechanical and electronic regulators.

- Have students complete Job Sheet 2.

Objective 8 Label parts of an alternator.

Objective 9 Arrange in order statements about the operation of an alternator.

- Have students use parts catalogs to compare alternators.

- Have examples of various types of alternators.

- Discuss the effect of electronics on alternators.

- Discuss the use of alternators rather than generators.

- To insure that students understand the role of the alternator, have them suggest other appliances that would be improved if alternators were added to them. Stipulate that some energy form that could be transformed to mechanical energy would be needed to power the alternator. Examples like flashlights will be excluded because they lack the recharging energy. Few acceptable examples may be suggested, but the complexity of the energy systems may be better understood.

- Have students complete Job Sheets 3 and 4.

APPLICATION

Objective 10 Diagnose charging system problems. (Assignment Sheet 1)

Objective 11 Demonstrate the ability to:

a. Perform output test. (Job Sheet 1)
b. Test the voltage regulator. (Job Sheet 2)
c. Remove and replace an alternator. (Job Sheet 3)
d. Service an alternator. (Job Sheet 4)

- Allow students to repeat procedures on a variety of alternator and regulator types.

- Show students electronic diagnostic procedures in addition to the tests listed in the unit.

- Relate the starter and alternator and compare function, parts, and servicing.
- Stress to students that the service manual must be followed during all testing and servicing procedures.

EVALUATION

Pretest

- Pretest qualifying students.
- Determine individual requirements from pretest results.
- Counsel students individually on pretest results and study requirements.
- Modify materials in unit or create supplementary materials for individual students as required.

Practical test

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.
- Complete appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

Publications

- *Engine Service and Maintenance Worksheets.* Worksheet Masters that can be duplicated for student use. Can be ordered single or in sets: "Battery Service & Maintenance," "Testing the Ignition System," and "Alternator Testing and Service." Contact HOBAR Publications, 1234 Tiller Lane, St. Paul, MN 55112, phone (612) 633-3170 for order numbers and prices.

- *Automotive Electricity and Electronics* by Al Santini. Text and Instructor's Guide covering the basics of electricity and circuitry; discusses solid state and semi-conductor theory; offers information on devices and circuitry on models through 1987. The book is well illustrated and offers laboratory activities and assignment questions. Instructor's guide has answers to questions and suggestions for lab activities. Order Nos: Text, 2489-8; Instructor's Guide, 2490-1. Available from HOBAR Publications, 1234 Tiller Lane, St. Paul, MN 55112, phone (612) 633-3170.

NOTE: The following items are available from General Motors Service Training Development Materials and Information. To order, contact General Motors Training Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28635 Mound Road, Warren, MI 48029 or by calling 1-800-468-6657.

- *Batteries, Charging, and Cranking* course materials includes the "description, operation, diagnosis, disassembly and repair of alternating generators and cranking motors. Emphasizes maintenance-free battery construction, operation, diagnosis and service." The set includes a 217 page Instructor's Guide and a set of over 100 transparencies. Order number GM-16021-01M.

- *Batteries, Charging, and Starting Systems.* This 126-page manual focuses on basic information and electricity. Details on maintenance-free batteries, Delcotron charging systems and cranking motors are also included. Order number GM-16021-011.

- *Technical Specifications Batteries Charging and Cranking* is a 33-page collection of service bulletins, testing procedures, troubleshooting data and specifications for batteries, charging, and starting systems. Order number GM-16021-012.

- *Technical Specifications Batteries Charging and Cranking* is an 108-page manual including service bulletins, testing procedures, troubleshooting data and specifications for batteries, charging and starting systems.

SUGGESTED RESOURCES

Media

NOTE: The following are available from Bergwell Productions, Inc., P.O. Box 238, Garden City, NY, 11530-0238 or call 1-800-645-3565 or Fax #516-222-9383.

- *The Charging System Explained* (#436X) is a seven-part video program covering:
  - "Generator—Regulator Operation"
  - "Alternator Construction"
  - "Alternator Operating Principles"
  - "Advanced Alternator Principles"
  - "Alternator Regulators: Vibrating Types"
  - "Electronic Regulators"
- *The Alternator Explained* (#439X) is a five-part series covering:
  - "Basic Parts and Principles"
  - "Charging Problems"
  - "Electrical and Mechanical Problems"
  - "Overhauling—Disassembly and Testing"
  - "Overhauling—Assembly"
- *Engine Electrical Systems* Transparencies. Set of transparencies and overlays on electricity, magnetism, typical electrical system, battery construction, battery visual checks, battery tests, starter construction, starting system tests, alternator construction, charging system tests. Available individually or as a set from HOBAR Publications, 1234 Tiller Lane, St. Paul, MN 55112, phone (612) 633-3170. Call or write for order numbers and prices.

- *Engine Electrical Systems.* Filmstrips on *Electricity* (Order No. AES-30), *Magnetism* (Order No. AES-31), *Typical Electrical System* (Order No. AES-32), *Battery Construction* (Order No. AES-33), *Battery Visual Checks* (Order No. AES-34), *Battery Tests* (Order No. AES-35), *Starter Construction* (Order No. AES-36), *Starting System Tests* (Order No. AES-37), *Alternator Construction* (Order No. AES-38), *Charging System* (Order No. AES-39), and 10 Transparencies with 3 Overlays. May be purchased separately or as a set. Available from DCA Educational Products, phone 1-800-345-3548.

- *Interstate Electrical Clinic Training Program.* Developed by Interstate Battery Systems of America to help students master AES competencies, this 6-part videotape program covers electrical diagnostic/troubleshooting, understanding/testing batteries, troubleshooting charging systems, troubleshooting starting system, troubleshooting voltage drops, and troubleshooting key-off battery drain. Includes a workbook. Available from Mitchell International, phone 1-800-854-7030.

Computer Software

- *Electrical Systems and Related Review.* Provides more than 400 questions that will help students review and help teachers write test questions. Covers fundamentals, storage batteries, charging, starting, ignition, lighting and accessory circuits. Available from Apple II, IBM, TRS and MacIntosh. Contact HOBAR Publications, 1234 Tiller Lane, St. Paul, MN 55112, phone (612) 633-3170 for order numbers and prices.

- *Electrical Systems*, 1989. Covers electrical system basics, starting systems, charging systems, ignition systems, and electrical systems. Five lessons and quizzes on two copyable disks for MacIntosh, IBM and Apple. Order No. SW320, available from Shopware Educational Systems, Department KL-3, 101 Hill Road, Aberdeen WA 98520-7302, phone (206) 532-3392.

UNIT REFERENCES

- deKryger, William J., et al. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Company, n.d.

- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.

- Duffy, James E. *Auto Electricity, Electronics, Computers.* South Holland, Illinois: Goodheart-Willcox Co., Inc., 1990.
- Todboldt, William K. *Automotive Encyclopedia.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1983.

CHARGING SYSTEM

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions.

Objective	Questions
1	1-3
2	4-6
3	7-10
4	11-12
5	13-15
6	16
7	16-20
8	21-22
9	23
10	24
11	25-30

ANSWER KEY

1. a
2. c
3. a
4. a
5. b
6. c
7. c
8. c
9. b
10. a
11. a
12. c
13. b
14. a
15. a
16. a
17. c
18. a
19. b
20. b
21. a
22. c
23. a
24. b
25. a
26. c
27. a
28. c

PRETEST

CHARGING SYSTEM

IV

NAME ______________________________ SCORE ________

______1. Alternating current ___.

a. flows in one direction, then the other
b. turns off and on
c. alternates between flowing and static current

______2. A diode ___.

a. is an electronic circuit protection device
b. increases voltage
c. allows current to flow one direction and not the other

______3. A piece of iron that is wrapped with a copper wire and becomes a magnet when current passes through the windings is called a(n) ___.

a. electromagnet
b. magnetic pole
c. magnetized piling

______4. The charging system converts ___.

a. mechanical energy to electrical energy
b. mechanical energy to chemical energy
c. electrical energy to chemical energy

______5. While the engine is running, the radio and other electrical components are powered by ___.

a. the battery
b. the charging system
c. converted ignition system power

______6. Excess current in the automobile goes to the ___

a. chassis (ground) and is dissipated
b. alternator
c. battery

______7. The charging system receives its initial energy from ___.

a. the mechanical power of the running engine
b. the spark of the ignition system
c. current from the battery

______8. The battery is considered part of the ___.

a. starting system
b. charging system
c. both a and b

______9. The alternator ___.

a. determines where the power for each automotive function will come from
b. supplies current to the ignition system, electrical accessories, and the battery
c. regulates the amount of voltage supplied by the charging system

_____10. The alternator is attached to the engine crankshaft by ___.

a. a belt and pulley
b. the voltage regulator
c. a series of gears

_____11. The first step in testing the charging system is checking the ___.

a. battery
b. alternator
c. starting system circuit for continuity

_____12. Common in-car charging system tests include ___.

a. field coil current draw test, stator winding tests, and voltage output test
b. diode test, field coil test, and field coil current draw test
c. voltage output test, current output test, and charging circuit resistance test

_____13. Short-trip driving ___.

a. may overcharge the battery
b. may undercharge the battery
c. should not affect the battery

_____14. A loose alternator belt will not properly turn the ___.

a. rotor
b. stator
c. rectifier

_____15. Alternator and voltage regulator problems may cause ___.

a. overcharging or undercharging
b. overcharging
c. undercharging

_____16. The voltage produced by the charging system ___.

a. may be more than is needed by the automobile
b. never exceeds the needs of the automobile
c. cannot meet the needs of the automobile

_____17. Possible results of excessive voltage include ___.

a. no damage to system
b. engine overheating
c. burned-out bulbs and damaged components

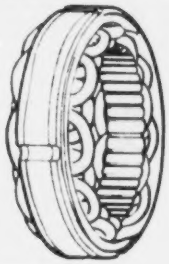
_____18. To regulate voltage, the regulator controls ___.

a. current from the battery to the alternator
b. current from the alternator to the battery
c. amperage in the battery

_____19. Modern regulators may cut off current ___.

a. if they are faulted or defective
b. hundreds of times per minute
c. if engine temperature exceeds manufacturer's specified limits

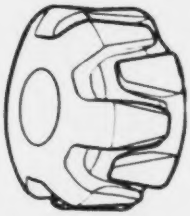
_____20. The part shown in this drawing is a ___.



Used with permission of Ford Motor Company.

a. rotor
b. stator
c. diode

_____21. The part shown in this drawing is a ___.



Used with permission of Ford Motor Company.

a. rotor
b. stator
c. diode

_____22. The electromagnet turning within the coils of the stator produces ___.

a. static electricity
b. magnetic energy
c. current

_____23. Common symptoms of charging system problems include ___.

a. frequent fuse burnouts
b. windshield wipers won't work when the car is running
c. poor mileage

_____24. During a charging system output test, adjustments are made to the ___.

a. engine speed and temperature
b. engine speed
c. temperature

_____25. Before testing a voltage regulator ___.

a. be sure the battery is fully charged and turn off all electric accessories and lights
b. disconnect the battery and turn on the headlights
c. remove the alternator and regulator

_____26. Before removing an alternator ___.

a. disconnect wires from the alternator
b. disconnect the battery ground and remove the belt
c. both a and b

_____27. Servicing the alternator does NOT include ___.

a. oiling brushes
b. visually inspecting the rotor
c. replacing bearings

_____28. Diodes must be tested twice. The readings should show ___.

a. exactly matching ohmmeter readings
b. zero resistance at all diodes
c. high resistance one direction, low resistance the other

INFORMATION SHEET

CHARGING SYSTEM

IV

OBJECTIVE 1

Match terms related to servicing the charging system to their correct definitions.

- **Alternating current** — Current that flows one way and then the other
- **Diode** — An electronic semiconductor device that allows current to flow only one direction
- **Direct current** — Current that flows one way only
- **Electromagnet** — A piece of iron that is wrapped with copper wire and becomes a magnet when current passes through the windings

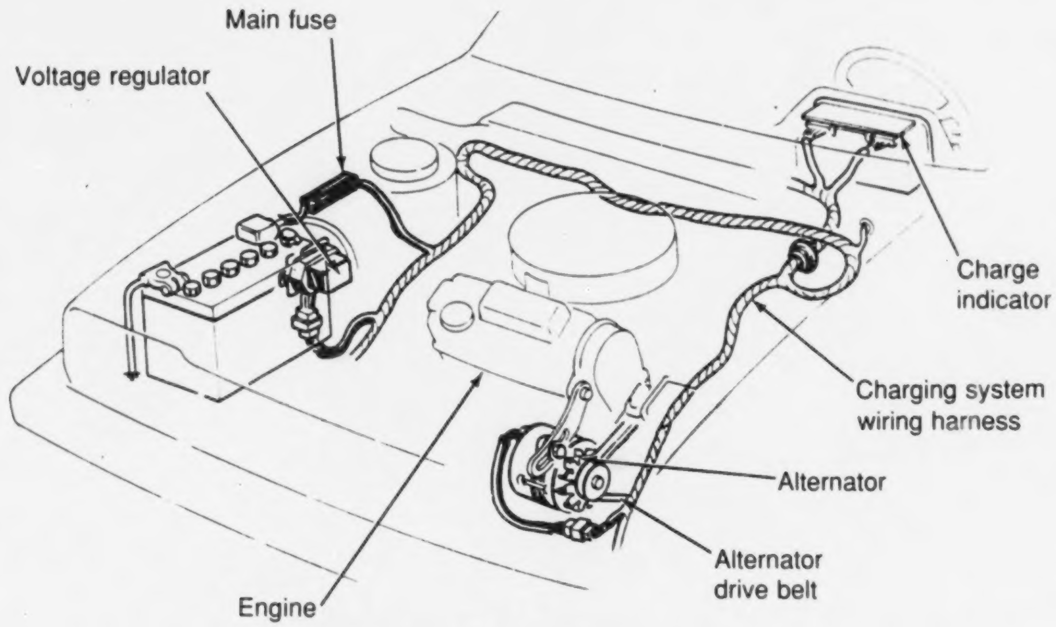
OBJECTIVE 2

Explain the purpose of the charging system.

- Recharges the battery
- Converts mechanical energy to electrical energy
- Supplies the automobile with electricity while the engine is running

NOTE: The battery provides initial electrical energy for starting the car. Once the car is started, electrical energy is provided by the alternator.

OBJECTIVE 3 **List the functions of charging system components.**

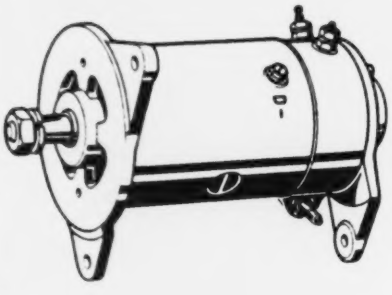

Main fuse
Voltage regulator
Charge indicator
Charging system wiring harness
Alternator
Alternator drive belt
Engine

Used with permission of American Honda Company.

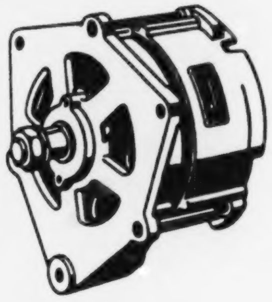
- **Battery**
  - Provides initial alternator current
  - Stabilizes alternator output
  - Converts electrical energy produced by alternator to chemical energy for storage
- **Alternator**
  - Converts mechanical energy to electrical energy
  - Supplies current to the ignition system, electrical accessories, and the battery

ALTERNATOR OR GENERATOR?

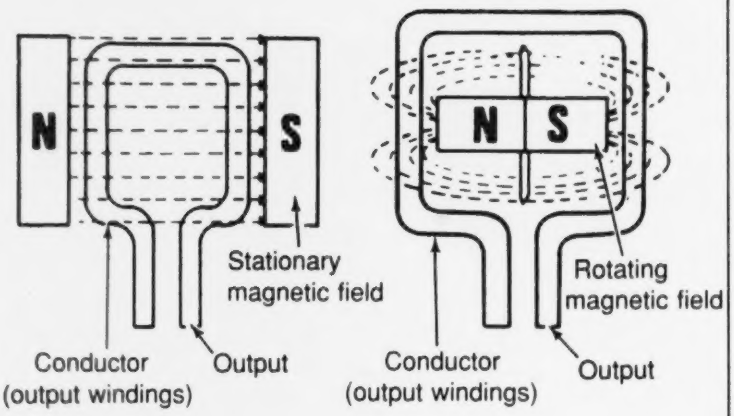
There are two types of charging systems: alternator (AC) and generator (DC). Today, alternators have replaced generators. Alternators are really a type of generator, and are sometimes called AC generators. Alternators and generators transform mechanical energy to electrical energy. Both use the principle that moving a coil of wire through a magnetic field produces electricity. The generator produces insufficient current when the engine idles. In today's stop-and-go traffic, most automobiles would draw upon the battery and discharge it if a generator, rather than an alternator, were used.



Generator



Alternator


N
S
Stationary magnetic field
Conductor (output windings)
Output
N
S
Rotating magnetic field
Conductor (output windings)
Output

The older generator included a stationary magnetic field with a rotating conductor while the alternator houses a stationary conductor and rotating magnetic field.

Used with permission of Ford Motor Company.

- **Voltage regulator**
  - Controls alternator's output voltage
- **Pulley and belt drive system**
  - Protects automotive components from damage caused by the alternator producing too much voltage
- **Alternator pulley and belt assembly**
  - Powers alternator
  - Links alternator pulley to engine crankshaft pulley
- **Fusible link**
  - Protects charging system circuits from overload
- **Dash warning light or ammeter**
  - Informs driver of charging system status
- **Charging system harness**
  - System wiring conducts current from load to load

OBJECTIVE 4 **Name charging system tests according to their descriptions.**

In-car tests

- **Pretest checks**
  - Check battery electrolyte and charge
  - Check battery visually
  - Check battery and circuit connections
  - Check drive belt tension

- **Charging circuit resistance test.**
  - Involves connecting an ammeter, voltmeter, tachometer, and carbon pile rheostat in the charging circuit

    NOTE: Most often these are combined in a volt-amp tester, electrical systems tester, or oscilloscope analyzer.
  - Engine speed is adjusted to manufacturer specifications
  - Amperage is adjusted to manufacturer's specs
  - Voltage drop is used to pinpoint circuit faults
- **Current output test**
  - Involves connecting a charging system tester (VAT)
  - Engine speed is adjusted to manufacturer's specs
  - Voltage is adjusted to manufacturer's specs
  - Current output is tested to meet manufacturer's specifications
  - Bench testing may be indicated
- **Voltage output test**
  - Checks that voltage readings are within specifications
  - This test is affected by battery charge status and regulator temperature

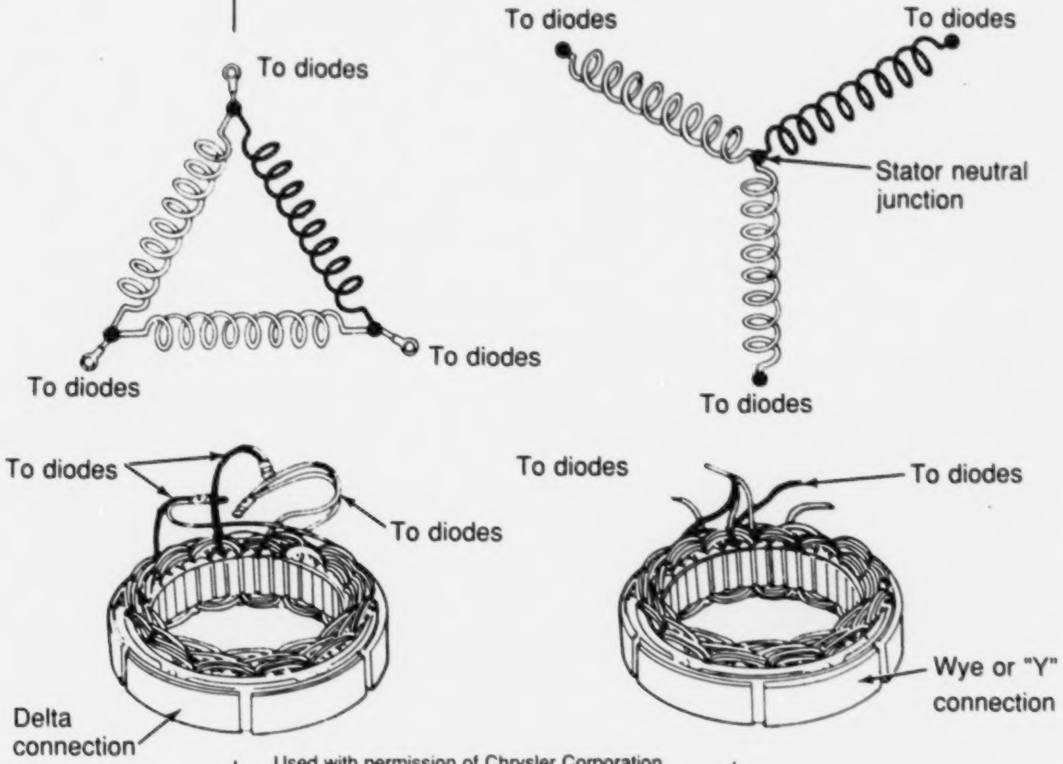
Bench tests

- **Field coil current draw test**
  - Involves connecting an ammeter, jumper wire, and voltmeter to the battery and/or alternator
  - Check brush to slip-ring contact
  - Voltage and amperage levels can be evaluated

- Can indicate high resistance faults in the rotor/field coil circuit, worn or defective brushes, corroded slip rings, poor connections, rotor coil problems, or open rotor winding coils

- **Diode test**
  - Uses a DVOM to test rectifier continuity through the diodes
  - Since the diode only allows current to flow in one direction, the DVOM will show continuity one direction and not the other.

- **Stator test (Y-connected models)**


To diodes
To diodes
To diodes
To diodes
To diodes
To diodes
Stator neutral junction
To diodes
To diodes
To diodes
To diodes
To diodes
Delta connection
Wye or "Y" connection

Used with permission of Chrysler Corporation.

NOTE: Stator winding coils have two possible configurations, Y and Delta. Y configuration is shaped like the letter "Y"; delta configuration is shaped like a triangle (the Greek letter Delta).

- Uses an ohmmeter to test stator winding for grounds or shorts.

- **Rotor test**

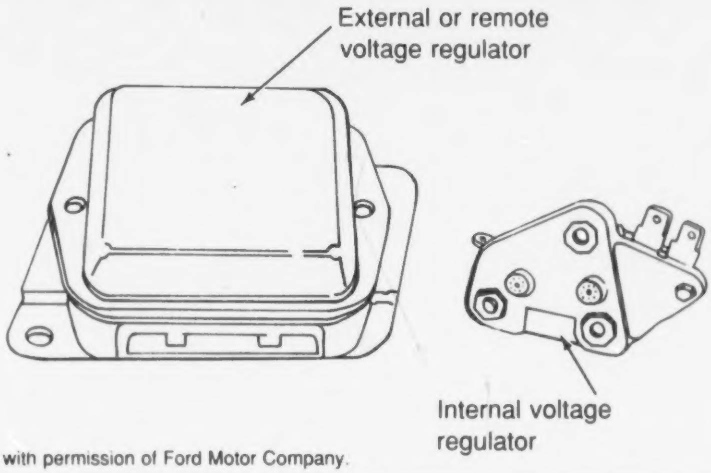
  - Uses an ohmmeter to test the rotor for grounds or shorts

OBJECTIVE 5 **Discuss causes of undercharging.**

The alternator is a battery maintainer—not a tool for battery maintenance. It cannot recharge a battery (without driving a *long* distance) and, in some cases, the auto's computer system prevents it from charging the battery to a level higher than the charge when the car was started.

- Frequent starts — Engine does not run long enough to allow charging system to recharge the battery
- Short-trip driving — Engine does not run long enough to allow the charging system to recharge the battery
- Faulty starter — May draw excessive current for starting
- Loose alternator drive belts — Do not turn alternator rotor properly and insufficient current is produced to recharge the battery
- Alternator problems — Brushes, rotor and stator windings, diodes and bearings must all perform properly or alternator output is affected
- Voltage regulator problems — Contact points (mechanical regulators) can become stuck or spring tension may decrease over time, preventing switches from opening and closing
- Faulty voltage regulator — Faulty field relay (mechanical regulators) switch may cause battery drain while the engine is not running

OBJECTIVE 6 **Label electronic and electromechanical voltage regulators.**


External or remote voltage regulator
Internal voltage regulator

Used with permission of Ford Motor Company.

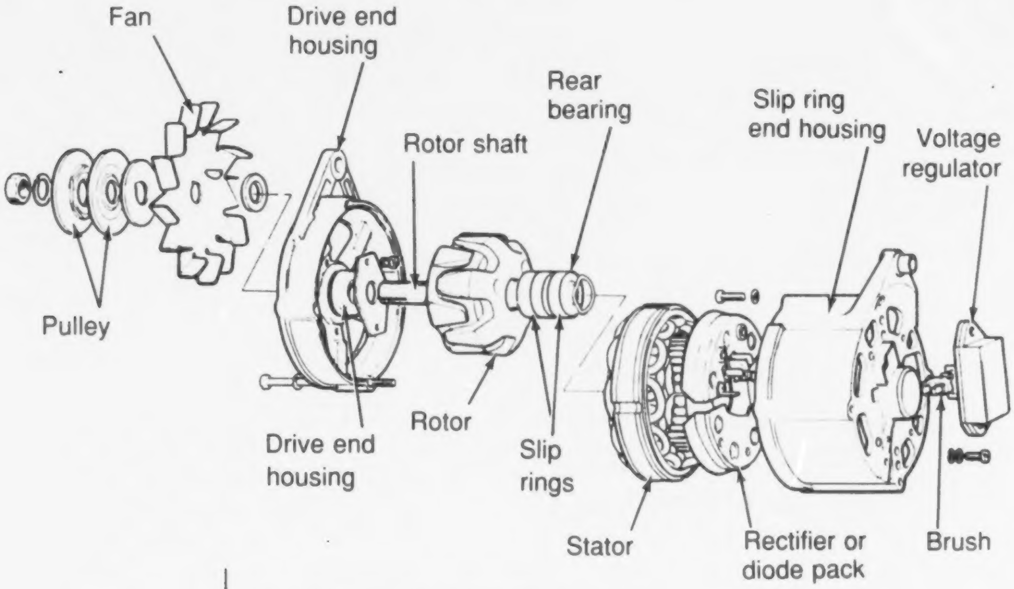
> Electromechanical regulators are larger than solid-state regulators. For this reason, they are usually housed outside the alternator. Their external mounting makes them more likely to be affected by dirt or vibration. Solid-state regulators are semi-conductor circuits sealed in plastic or metal. They may be housed outside the alternator, like electromechanical regulators, or may be housed inside the alternator, or may be housed inside the internal computer.

OBJECTIVE 7 **Select from a list true statements about the operation of a voltage regulator.**

The voltage produced by the alternator may be more than is needed by the automobile. If the engine is running at high speeds, more voltage can be produced. Similarly, if the battery is fully charged, the extra current produced by the alternator cannot be stored. Excessive current flowing through automotive systems can damage components such as radios and can burn out bulbs. The voltage regulator protects the automobile from excessive current and the damage that can result.

To control alternator output, regulators control the current flowing from the battery, through the brushes and slip rings, and to the rotor. When the rotor voltage is lowered, the electromagnetic field is affected and current production is decreased. A modern regulator may actually turn the current off and on hundreds of times per minute.

OBJECTIVE 8 **Label parts of an alternator.**


Fan
Drive end housing
Rear bearing
Slip ring end housing
Voltage regulator
Rotor shaft
Pulley
Drive end housing
Rotor
Slip rings
Stator
Rectifier or diode pack
Brush

Used with permission of Ford Motor Company.

- Stator
- Rotor
- Diode (rectifier) assembly
- Brush assembly

- Drive end housing
- Fan
- Pulley
- Integral regulator
- Slip rings
- Rear bearing
- Slip ring end housing

OBJECTIVE 9

Arrange in order statements about the operation of an alternator.

NOTE: The alternator is similar to a starter. Both use a coil in a magnetic field to convert energy. The starter converts electrical energy to mechanical energy; the alternator converts mechanical to electrical.

1. The running engine turns the crankshaft
2. The attached alternator belt turns the alternator pulley.
3. The pulley turns the fan and rotor shaft.
4. The rotor turns.
5. A small amount of current flowing from the battery to the rotor through the brushes and slip rings makes the rotor act as an electromagnet.
6. The electromagnet turning within the coils of the stator produces current.
7. The current flows from the stator to the rectifier or diode pack.
8. The diodes or rectifier transform the AC to DC and send the current from the alternator to the load or battery.

CHARGING SYSTEM DIAGNOSIS

CONDITION	POSSIBLE SOURCE	ACTION
• Battery does not stay charged — engine starts OK	• Battery	• Test battery replace if necessary
	• Loose or worn alternator belt	• Adjust or replace belt
	• Wiring or cables	• Service as required
	• Alternator	• Test and or replace components as required
	• Regulator	• Test. replace if necessary
	• Other vehicle electrical systems	• Check other systems for current draw Service as required
• Alternator noisy	• Loose or worn alternator belt	• Adjust tension or replace belt
	• Bent pulley flanges	• Replace pulley
	• Alternator	• Service or replace alternator
• Lights and or fuses burn out frequently	• Wiring	• Service as required
	• Alternator Regulator	• Test. service. replace if necessary
	• Battery	• Test. replace if necessary
• Charge indicator light flickers after engine starts or comes on while vehicle is being driven	• Loose or worn alternator belt	• Adjust tension or replace
	• Alternator	• Service or replace
	• Field circuit ground	• Service or replace defective wiring
	• Regulator	• Test. replace if necessary
	• Lamp circuit wiring and connector	• Service as required
• Charge indicator light flickers while vehicle is being driven	• Loose or worn alternator belt	• Adjust tension or replace belt
	• Loose or improper wiring connections	• Service as required
	• Alternator	• Service or replace
	• Regulator	• Test. replace if necessary
• Charge indicator gauge shows discharge	• Loose or worn alternator belt	• Adjust tension or replace belt
	• Wiring (Battery to alternator for ground or open)	• Service or replace wiring
	• Field circuit ground	• Service or replace damaged wiring
	• Alternator	• Service or replace
	• Regulator	• Test. replace if necessary
	• Charge indicator gauge wiring and connections	• Service as required
	• Gauge	• Replace gauge
	• Other vehicle electrical systems malfunction	• Service as required

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ASSIGNMENT SHEET 1

CHARGING SYSTEM

IV

NAME ______________________ SCORE ________

OBJECTIVE 10 **Diagnose charging system problems.**

INTRODUCTION Using the symptoms of a charging system problem will assist in servicing and repair. Charging system problem symptoms tend to be associated with the performance of electric components or accessories, the battery's state of charge, frequency of fuse burnouts, and alternator noises.

DIRECTIONS Use the chart in Supplement 1 to answer the questions below.

1. What are the possible sources of a noisy alternator?

2. What conditions can be caused by a defective battery?

3. What conditions may require adjusting the belt?

4. If the charge indicator gauge shows discharge, what charging system component may need to be tested?

____

5. What condition may be caused by a field circuit ground or a lamp circuit wiring and connector problem?

____

____

6. If the charge indicator light flickers while the vehicle is being driven, what are the possible sources of the problem?

____

____

____

____

7. When fuses burn out repeatedly, what service actions are indicated?

____

____

____

8. If the battery does not stay charged but the engine starts, can you be sure the problem is in the charging system?

____

CHARGING SYSTEM

ASSIGNMENT SHEET 1

1. Loose or worn alternator belt
   Bent pulley flanges
   Alternator

2. Battery does not stay charged—engine starts OK
   Lights and/or fuses burn out frequently

3. Battery does not stay charged
   Alternator noisy
   Charge indicator light flickers after engine starts or comes on while vehicle is being driven.
   Charge indicator light flickers while vehicle is being driven
   Charge indicator gauge shows discharge.

4. Regulator

5. Charge indicator light flickers after engine starts or comes on while vehicle is being driven

6. Loose or worn alternator belt
   Loose or improper wiring connections
   Alternator
   Regulator

7. Service wiring as required
   Test, service, replace alternator/regulator
   Test battery, replace if necessary

8. No

JOB SHEET 1

CHARGING SYSTEM

IV

OBJECTIVE 11a

Perform output test.

TOOLS AND EQUIPMENT

- Service manual
- Jumper wire
- Tachometer
- Safety glasses
- Fender covers

PROCEDURE

NOTE: These instructions are only meant to describe basic test procedures. Before performing any test procedure, consult the manufacturer's service manual. Follow testing procedures and specifications listed there.

1. Refer to the correct service manual.

2. Refer to VAT operator's instruction manual to connect and operate volt-amp tester.

3. Following manufacturer's instructions, connect a tachometer to test engine speed.

   NOTE: If the automobile does not have a tachometer, it may be necessary to connect one before the test is performed. Follow manufacturer's instructions for tachometer installation.

4. Start the engine and allow it to slow to idling speed to bring the engine to operating temperature.

5. Following VAT manual instructions, complete testing.

   ♦ WARNING ♦

   Do not allow voltage to exceed 16 volts. Higher voltage may damage components.

6. Check current output. It should register on the ammeter within manufacturer's specifications.

7. If output is less the manufacturer's specifications, bench test the alternator.

8. Have your instructor check your work.

9. Put away tools and materials and clean the work area.

JOB SHEET 2

CHARGING SYSTEM

IV

OBJECTIVE 11b

Test voltage regulator.

TOOLS AND EQUIPMENT

- Service manual
- Basic tools
- Hydrometer
- Voltmeter
- Thermometer
- Safety glasses
- Fender covers

PROCEDURE

NOTE: Do not use this description as instructions for performing this or any other test. Testing and servicing procedures found in the manufacturer's service manual should always be followed.

NOTE: If the automobile does not have a tachometer, it may be necessary to connect one before the test is performed. Follow manufacturer's instructions for tachometer installation.

1. Refer to the proper service manual.
2. Check the battery state of charge and bring it to specs, if necessary.
3. Follow service manual procedures for testing the voltage regulator.
4. Have your instructor check your work.
5. Put away tools and materials and clean the work area.

JOB SHEET 3

CHARGING SYSTEM

IV

OBJECTIVE 11c

Remove and replace alternator.

TOOLS AND EQUIPMENT

- Service manual
- Basic tools
- Safety glasses
- Belt tension gauge
- Fender covers
- Seat covers
- Floor mats

PROCEDURE

Removal

1. Refer to service manual.
2. Disconnect the battery ground.
3. Loosen bolts holding alternator in place.
4. Remove belt.
5. Disconnect wires from the alternator. Note and mark their locations.
6. Remove bolts.
7. Lift out alternator.

PROCEDURE

Installation

1. Refer to service manual instructions.
2. Fit alternator into place.
3. Reconnect wires to the proper location.
4. Hand start bolts. Do not tighten them.
5. Check alternator belt. Replace it if needed.
6. Slip belt over pulley.
7. Make sure belt is aligned and adjust it to proper tension.

8. Tighten bolts.
9. Have your instructor check your work.
10. Reconnect battery.
11. Start the vehicle to check proper installation.
12. Put away tools and materials and clean the work area.

JOB SHEET 4

CHARGING SYSTEM

IV

OBJECTIVE 11d

Service alternator.

TOOLS AND EQUIPMENT

- Service manual
- Work bench with vise
- Various-sized wrenches
- Bearing puller
- Plastic or brass hammer
- Ohmmeter
- 12-volt battery
- Ammeter
- Jumper wires
- Test lamp
- Calipers
- Safety glasses
- Fender covers

PROCEDURE

1. Refer to the proper service manual.

bench.

2. Remove alternator from the car and place it on the work
3. Scribe marks on the outside of the assembly to help you reassemble the housing correctly.

4. Clamp the alternator front housing mounting flange in the vise, being careful not to damage the fan or housing.

5. Disassemble the alternator according to directions in the manufacturer's service manual. As you disassemble, place the pieces on the workbench in order of removal. This will make reassembly easier.

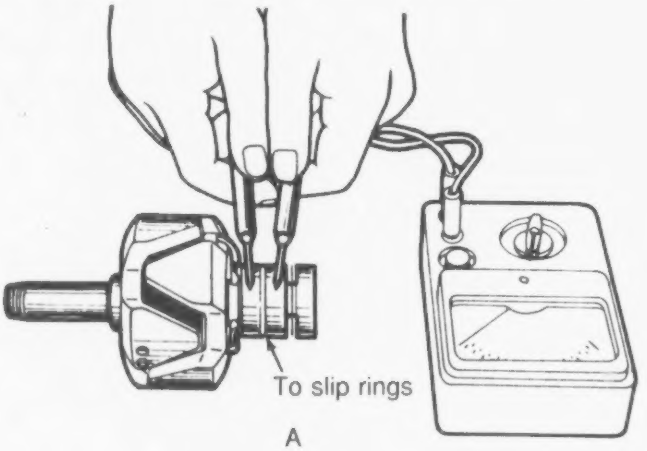
   NOTE: Keep the parts clean. Be sure grease and oil does not get on the brushes. Do not soak electrical components such as the rotor, stator, diode pack, or voltage regulator in solvent.

PROCEDURE

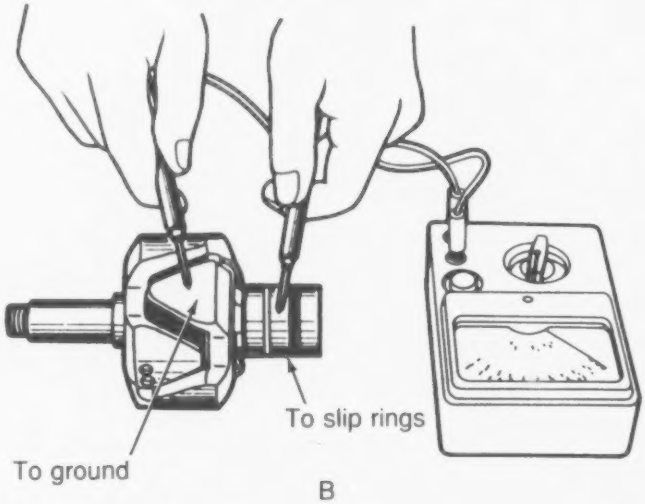
Test rotor

NOTE: If the rotor fails any of these tests it should be replaced.

1. Inspect the rotor visually. Be sure to check for a bent shaft and for worn or damaged slip rings.
2. Check rotor windings for grounds.
   a. Set ohmmeter to X1000.
   b. Attach one ohmmeter lead to the rotor shaft, the other to the slip rings.
   c. Read ohmmeter. Infinite resistance means no grounds. (Continue to next step.)



A



B

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3. Check rotor windings for open circuits.

    a. Set ohmmeter at X1.

    b. Attach one ohmmeter lead to a slip ring, the other to another slip ring.

    c. Read ohmmeter. Low resistance (2-4 ohms) means no open circuits. (Continue to next step.)

4. Check rotor windings for shorts.

    a. Set ammeter to low scale

    b. Attach one lead of the ammeter to slip rings, the other to a 12-volt battery.

    c. Attach a jumper wire to the battery and to slip rings.

    d. Measure current and compare it to manufacturer's specifications. (Rotor good, no trouble found, continue on.)

PROCEDURE

Test Stator

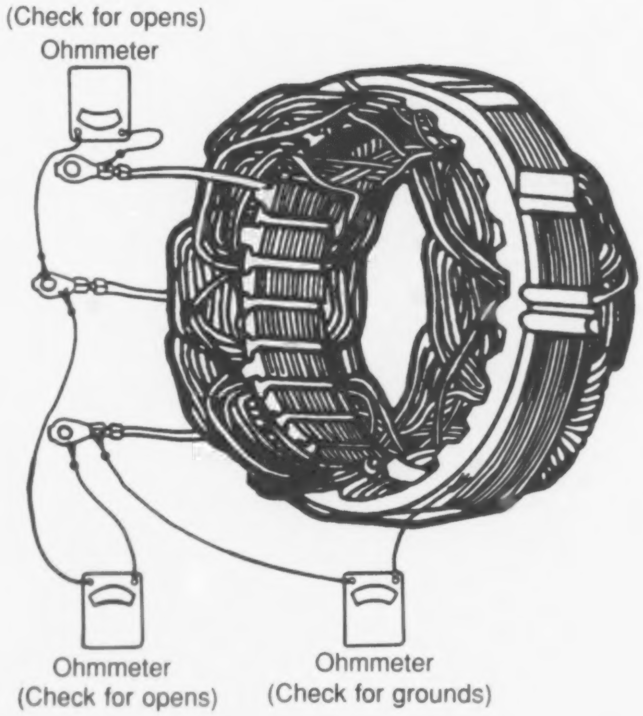
1. Visually check stator for signs of burning. (Continue to next step.)

2. Check stator for open circuits.

    a. Set ohmmeter at XI.

    b. Connect each ohmmeter lead to a stator lead.

    NOTE: There are three stator leads, so this test will have to be repeated. Connect the ohmmeter to two leads, then disconnect one ohmmeter lead and reconnect it to the untested stator lead.


(Check for opens)
Ohmmeter
Ohmmeter
(Check for opens)
Ohmmeter
(Check for grounds)

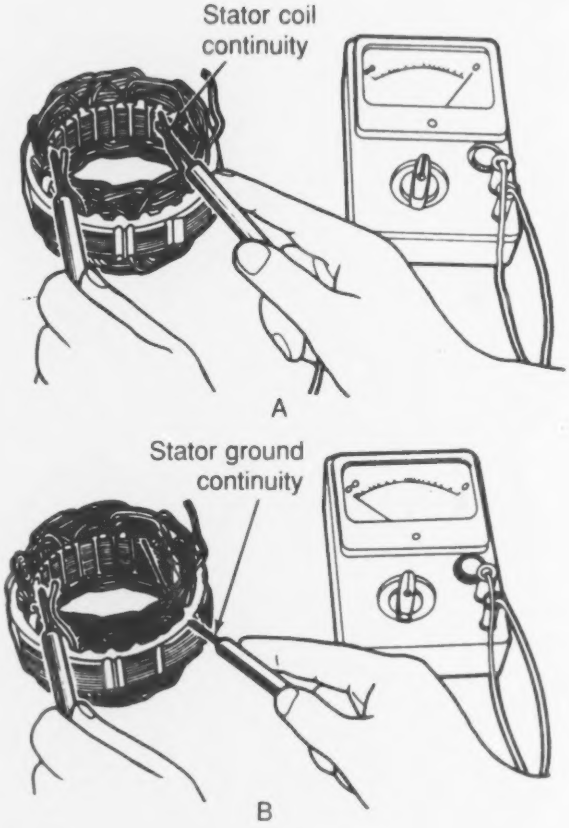
Used with permission of General Motors Corporation.

    b. Read ohmmeter. Infinite resistance means windings are broken. (Continue to next step)

3. Check stator for grounded windings.

    a. Connect one lead of the ohmmeter to one of the stator leads. Connect the other ohmmeter lead to the stator housing.

b. Read the ohmmeter. Low resistance indicates grounded windings.


Stator coil continuity
A
Stator ground continuity
B

Used with permission of Chrysler Corporation.

NOTE: If the stator fails either of these tests, it should be replaced. (Continue testing.)

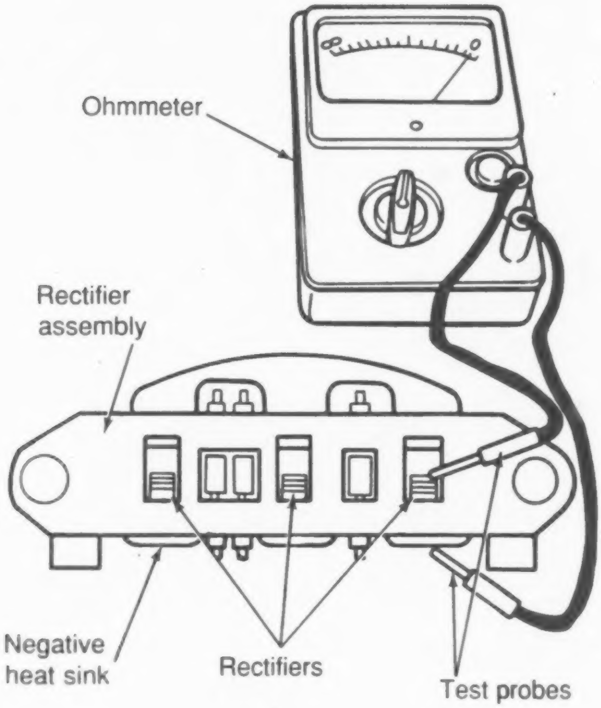
PROCEDURE

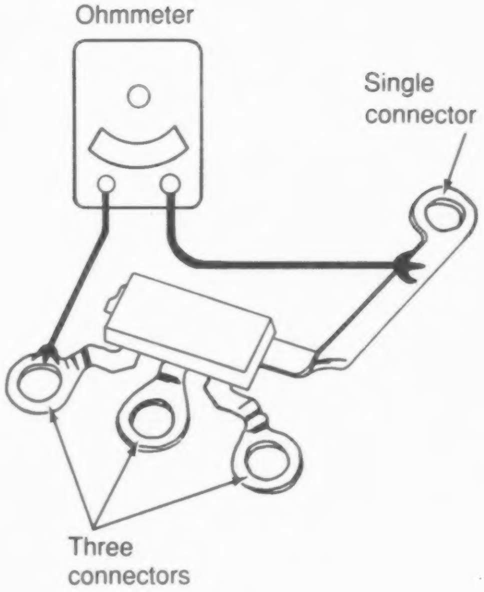
Test alternator diode.

NOTE: Diodes must be tested according to manufacturer's specifications. Commonly they are tested with special diode testers, but may be tested with an ohmmeter or test light.

If testing with a meter:

1. Attach leads as instructed in service manual


Ohmmeter
Rectifier assembly
Negative heat sink
Rectifiers
Test probes


Ohmmeter
Single connector
Three connectors

Used with permission of Chrysler Corporation.

2. Read meter.

3. Reverse leads.

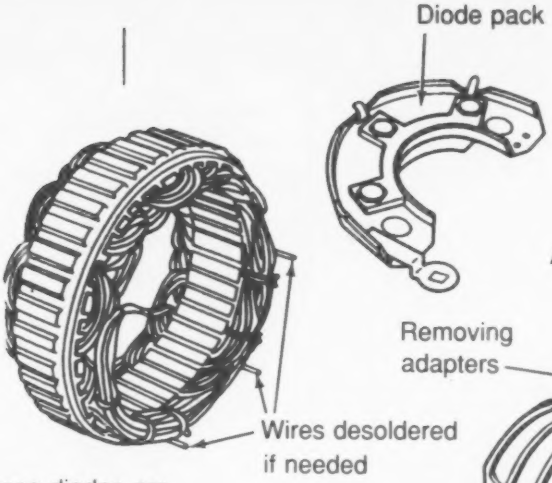
4. Read meter again.

5. Compare readings:

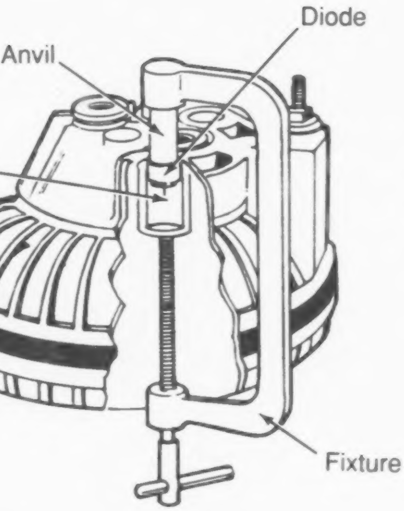
    a. If the diodes are operating properly, resistance will be high in one reading and low in the other.

    b. If resistance is high both ways the diode is open.

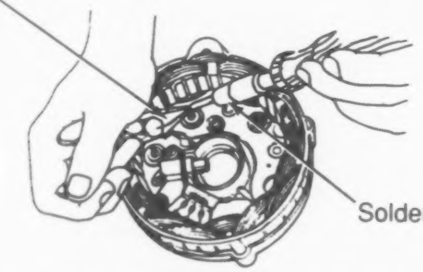
    c. If resistance is low both ways it has shorted.


Diode pack
Wires desoldered if needed

A—These diodes are replaced as a set.


Diode
Anvil
Removing adapters
Fixture

B—These diodes must be pressed out individually.


Pull on lead to desolder
Soldering iron

C—Wires can be soldered to diode pack. Use needle nose pliers to grasp wires as they are desoldered. This will help prevent too much heat from entering and ruining good diodes.

Used with permission of General Motors Corporation.

Used with permission of Chrysler Corporation.

CAUTION

If you have to remove diodes during manufacturer's recommended testing, be sure you use rosin core solder and sink diode leads when soldering. Work quickly to avoid overheating diodes which can damage them.

PROCEDURE

Service the alternator bearing

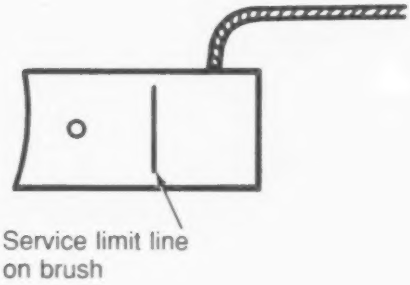
1. Remove front and rear bearings according to manufacturer's directions.
2. Check front bearing action by rotating it on your finger and checking for areas that are rough or dry.

NOTE: Bearings are commonly replaced anytime the alternator is serviced.

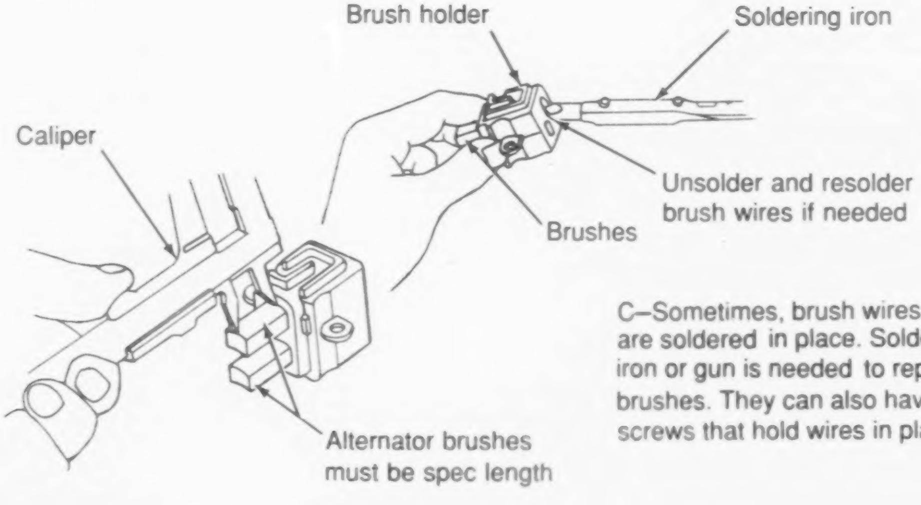
PROCEDURE

Alternator brush service

1. Visually inspect brushes. Brushes should not be overly worn or covered in grease.
2. Replace brushes if necessary.


Service limit line on brush

A—This brush has factory line on it that shows point of maximum wear.


Brush holder
Soldering iron
Caliper
Unsolder and resolder brush wires if needed
Brushes
Alternator brushes must be spec length

C–Sometimes, brush wires are soldered in place. Soldering iron or gun is needed to replace brushes. They can also have screws that hold wires in place.

B—Calipers can also be used to measure length for comparing to specs.

Used with permission of Chrysler Corporation.

PROCEDURE

Reassembly and reinstallation

1. Reassemble alternator according to manufacturer's directions. Use scribe marks to match housing pieces.
2. Test alternator on a bench tester, if available.
3. Reinstall alternator.
4. Have your instructor check your work.
5. Test the alternator on the car. (Refer to Job Sheet 1.)
6. Put away tools and materials and clean the work area.

PRACTICAL TEST 1

CHARGING SYSTEM

IV

JOB SHEET 1

Perform output test.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Connected and used VAT according to manufacturer's instructions.	_____	_____
2. Connected a tachometer to test engine speed according to manufacturer's directions.	_____	_____
3. Started the engine and allowed it to idle.	_____	_____
4. Checked current output and compared it to manufacturer's specifications.	_____	_____
5. Used proper tools correctly.	_____	_____
6. Performed steps in a timely manner.	_____	_____
7. Practiced safety rules throughout procedure.	_____	_____
8. Provided satisfactory responses to questions asked.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Connected and used VAT correctly	4	3	2	1
Connected tachometer to manufacturer's specifications	4	3	2	1
Started engine and slowed to idle speed	4	3	2	1
Compared amperage to manufacturer's specifications and made appropriate conclusions	4	3	2	1

EVALUATOR'S COMMENTS

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 2

CHARGING SYSTEM

IV

JOB SHEET 2

Test voltage regulator.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Checked battery state of charge and made necessary adjustments.	____	____
2. Tested the voltage regulator, according to service manual procedures.	____	____
3. Used proper tools correctly.	____	____
4. Performed steps in a timely manner.	____	____
5. Practiced safety rules through procedure.	____	____
6. Provided satisfactory responses to questions asked.	____	____
7. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Tested battery correctly with no review	4	3	2	1
Tested voltage regulator	4	3	2	1
Followed service manual instructions	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3

CHARGING SYSTEM

IV

JOB SHEET 3

Remove and replace alternator.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
Removal:		
1. Disconnected the battery.	_____	_____
2. Loosened bolts holding alternator in place.	_____	_____
3. Removed belt.	_____	_____
4. Disconnected wires from the alternator.	_____	_____
5. Noted position of wires.	_____	_____
6. Removed bolts.	_____	_____
7. Lifted out alternator.	_____	_____
Installation:		
1. Fit alternator into place.	_____	_____
2. Installed wires to alternator.	_____	_____
3. Hand started bolts.	_____	_____

	YES	NO
4. Checked alternator belt and replaced it, if needed.	____	____
5. Slipped belt over pulley.	____	____
6. Made sure belt was aligned and adjusted.	____	____
7. Tightened bolts.	____	____
8. Reconnected battery.	____	____
Overall		
1. Used proper tools correctly.	____	____
2. Performed steps in a timely manner.	____	____
3. Practiced safety rules throughout procedure.	____	____
4. Provided satisfactory responses to questions asked.	____	____
5. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Disconnected battery and removed belt with ease	4	3	2	1
Noted position of wires carefully	4	3	2	1
Removed alternator and fit it back into place easily	4	3	2	1
Inspected and replaced as necessary	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 4

CHARGING SYSTEM

IV

JOB SHEET 4

Service alternator.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
Disassembly:		
1. Removed alternator.	_____	_____
2. Scribed marks on the outside of the assembly.	_____	_____
3. Clamped the alternator in the vise.	_____	_____
4. Disassembled the alternator according to directions in the manufacturer's service manual.	_____	_____
5. Placed the pieces on the workbench in order of removal.	_____	_____
Test rotor:		
1. Inspected the rotor visually.	_____	_____
2. Checked rotor windings for grounds.	_____	_____
3. Checked rotor windings for open circuits.	_____	_____
4. Checked rotor windings for shorts.	_____	_____

	YES	NO
Test stator:		
1. Visually checked stator for signs of burning.	_____	_____
2. Checked stator for open circuits.	_____	_____
3. Checked stator for grounded windings.	_____	_____
Test alternator diode:		
1. Tested alternator diode.	_____	_____
Alternator brush assembly:		
1. Serviced the alternator bearing.	_____	_____
2. Serviced the alternator brushes.	_____	_____
Reassembly:		
1. Reassembled the alternator.	_____	_____
2. Tested alternator on a bench tester.	_____	_____
3. Reinstalled the alternator.	_____	_____
Overall:		
1. Used proper tools correctly.	_____	_____
2. Performed steps in a timely manner.	_____	_____
3. Practiced safety rules throughout procedure.	_____	_____
4. Provided satisfactory responses to questions asked.	_____	_____
5. Put away tools and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Disassembled alternator	4	3	2	1
Tested rotor	4	3	2	1
Tested stator	4	3	2	1
Tested diode	4	3	2	1
Tested brush assembly	4	3	2	1
Reassembled alternator	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

CHARGING SYSTEM

IV

NAME ______________________________ SCORE ______

OBJECTIVE 1

Match terms related to servicing the charging system to their correct definitions. Write the correct letters in the blanks.

_____1. Current that flows one way only

_____2. An electronic semiconductor device that allows current to flow only one direction and rectifies AC to DC

_____3. Current that flows one way and then the other

_____4. A piece of iron that is wrapped with copper wire and becomes a magnet when current passes through the windings

a. Alternating current
b. Static electricity
c. Diode
d. Direct current
e. Magnetic field
f. Electromagnet
g. Relay

OBJECTIVE 2

Explain the purpose of the charging system.

____

____

____

OBJECTIVE 3

List the functions of charging system components.

1. **Battery**

____

____

____

2. **Alternator**

____

____

3. **Voltage regulator**

____

4. **Pulley and belt drive system**

____

____

5. **Alternator pulley and belt assembly**

____

____

6. **Fusible link**

____

7. **Dash warning light or ammeter**

____

8. **Charging system harness**

____

OBJECTIVE 4

Name charging system tests according to their descriptions. Using the information given, write the name of the test being performed in the blank.

1. Test name: ______________________________________

   - Check battery electrolyte and charge
   - Check battery visually
   - Check battery and circuit connections

- Check drive belt tension

2. Test name: ____________________________________

   - Involves connecting an ammeter, voltmeter, tachometer, and carbon pile rheostat in the charging circuit
   - Engine speed is adjusted to manufacturer specifications
   - Amperage is adjusted to manufacturer's specs
   - Voltage drop is used to pinpoint circuit faults

3. Test name: ____________________________________

   - Involves connecting an ammeter, tachometer, and carbon pile rheostat in the charging circuit
   - Engine speed is adjusted to manufacturer's specs
   - Voltage is adjusted to manufacturer's specs
   - Current output is tested to meet manufacturer's specifications
   - Bench testing may be indicated

4. Test name: ____________________________________

   - Checks that voltage readings are within specifications
   - This test is affected by battery charge status and regulator temperature

5. Test name: ____________________________________

   - Involves connecting an ammeter, jumper wire, and voltmeter to the battery and/or alternator
   - Check brush to slip ring contact
   - Voltage and amperage levels can be evaluated

- Can indicate high resistance faults in the rotor/field coil circuit, worn or defective brushes, corroded slip rings, poor connections, rotor coil problems, or open rotor winding coils

6. Test name: ________________________________

   - Uses a DVOM to test rectifier continuity through the diodes
   - Since the diode only allows current to flow in one direction, the test lamp should work when test lamp leads are properly placed, but not when the leads are reversed

7. Test name: ________________________________

   - Uses a test lamp or ohmmeter to test stator winding for grounds or shorts

8. Test name: ________________________________

   - Uses an ohmmeter to test the rotor for grounds or shorts

OBJECTIVE 5 **Discuss causes of undercharging.**

____

____

____

____

____

____

____

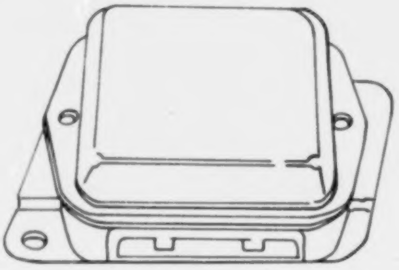
____

____

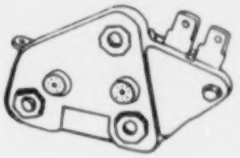
____

OBJECTIVE 6

Label electronic and electromechanical voltage regulators.



1.____________



2.____________

OBJECTIVE 7

Select from a list true statements about the operation of a voltage regulator. Write an "X" in the blank before each true statement.

______1. The voltage produced by the alternator may be more than is needed by the automobile.

______2. Engine speed has no effect on the amount of current produced.

______3. Similarly, if the battery is fully charged, the extra current produced by the alternator cannot be stored.

______4. Allowing excessive current to flow through automotive systems can lead to battery explosion.

______5. The alternator stator protects the automobile from excessive current and the damage that can result.

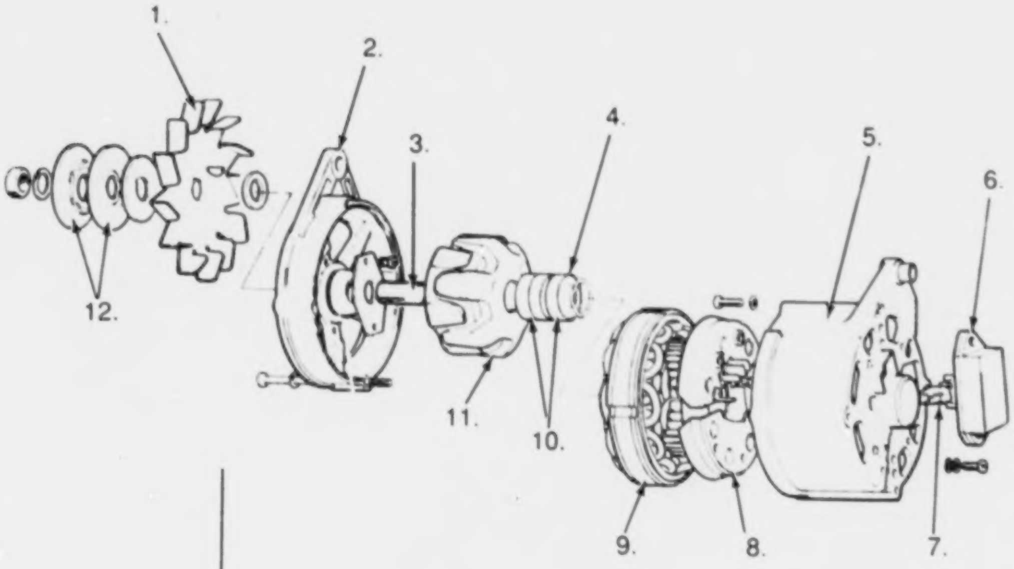
______6. To control alternator output, regulators control the current flowing from the alternator to the battery through the brushes and slip rings.

______7. When the rotor voltage is lowered, the electromagnetic field is affected and current production is decreased.

_____8. A modern regulator can only turn current on and off 10-12 times per minute.

OBJECTIVE 8 **Label parts of an alternator.**

- Drive end housing
- Voltage regulator
- Brushes
- Slip rings
- Rectifier or diode pack
- Rear bearing
- Rotor shaft
- Pulley
- Fan
- Rotor
- Stator
- Slip ring bearing



1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________
7. ____________
8. ____________
9. ____________
10. ____________
11. ____________
12. ____________

OBJECTIVE 9 **Arrange in order statements about the operation of an alternator.** Write a "1" in the blank before the first step, a "2" before the second, etc.

______1. Electromagnet turning within the coils of the stator produces current.

______2. The attached alternator belt turns the alternator pulley.

______3. The running engine turns the crankshaft.

______4. Current flows from the stator to the rectifier or diode pack.

______5. The pulley turns the fan and rotor shaft.

______6. The diodes or rectifier transform the AC to DC and send the current from the alternator to the regulator.

______7. A small amount of current flows from the battery to the rotor through the brushes and slip rings.

______8. The rotor turns.

______9. Current makes the rotor act as an electromagnet.

NOTICE The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.

OBJECTIVE 10	**Diagnose charging system problems.**	SCORE ______
OBJECTIVE 11a	**Perform output test.**	RATING ______
OBJECTIVE 11b	**Test voltage regulator.**	RATING ______
OBJECTIVE 11c	**Remove and replace alternator.**	RATING ______
OBJECTIVE 11d	**Service alternator.**	RATING ______

CHARGING SYSTEM

OBJECTIVE 1

1. d
2. f
3. a
4. c

OBJECTIVE 2

- Recharges the battery
- Converts mechanical energy to electrical energy
- Supplies automobile with electricity while the engine is running.

OBJECTIVE 3

1. Battery:
    - Provides initial alternator current.
    - Stabilizes alternator output.
    - Converts electrical energy produced by alternator to chemical energy for storage.
2. Alternator:
    - Converts mechanical energy to electrical energy.
    - Supplies current to the ignition system, electrical accessories, and the battery.
3. Voltage regulator:
    - Controls alternator's output voltage.
4. Pulley and drive belt system:
    - Protects automotive components from damage caused by alternator overproduction of voltage.
5. Alternator pulley and belt assembly:
    - Powers alternator.
    - Links alternator pulley to engine crankshaft pulley.
6. Fusible link:
    - Protects charging system circuits.

7. Dash warning light or ammeter:

   - Informs driver of charging system status.

8. Charging system harness:

   - System wiring conducts current from load to load.

OBJECTIVE 4

1. Pre-test checks
2. Charging circuit resistance test
3. Current output test
4. Voltage output test
5. Field coil current draw test
6. Diode test
7. Stator test
8. Rotor test

OBJECTIVE 5

Discussion should include the following points:

- **Undercharging**

  - Frequent starts—engine does not run long enough to allow charging system to recharge the battery.

  - Short-trip driving—engine does not run long enough to allow the charging system to recharge the battery

  - Faulty starter—may draw excessive current for starting.

  - Loose alternator drive belts—does not turn alternator rotor properly and insufficient current is produced to recharge the battery

  - Alternator problems—brushes, rotor and stator windings, diodes and bearings must all perform properly or alternator output is affected.

  - Voltage regulator problems—contact points can become stuck or spring tension may decrease over time, preventing switches from opening and closing.

OBJECTIVE 6

1. External or remote voltage regulator
2. Internal voltage regulator

OBJECTIVE 7

1, 3, 7

OBJECTIVE 8

1. Fan
2. Drive end housing
3. Rotor shaft
4. Rear bearing
5. Slip ring end housing
6. Voltage regulator
7. Brushes
8. Rectifier or diode pack
9. Stator
10. Slip rings
11. Rotor
12. Pulley

OBJECTIVE 9

1. 3
2. 2
3. 5
4. 8
5. 7
6. 9
7. 1
8. 4
9. 6

OBJECTIVE 10

Refer to Answers to Assignment Sheet 1.

OBJECTIVE 11

Refer to Practical Tests for Job Sheets 1-4.

OBJECTIVE SHEET

LIGHTING SYSTEM

V

INTRODUCTION

The automotive lighting system includes interior and exterior lights. Some are designed for safety, some for utility, and some for comfort. Since many lighting systems share components or circuitry, diagnosis and service may seem complicated, but are not. Although specific testing and repair procedures vary among makes and models, basic testing and servicing require only an understanding of electrical functions, a test lamp, a service manual, a wiring diagram and a multimeter.

UNIT OBJECTIVE

After completing this unit, the student should be familiar with lighting terms and subsystems, as well as diagnostic, inspection, and service procedures. The student will demonstrate these competencies by completing assignments sheets, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Complete statements about headlight systems.
2. Match names and descriptions of exterior lighting systems.
3. Describe interior lighting systems.
4. Diagnose headlight problems. (Assignment Sheet 1)
5. Diagnose taillight/parking light problems. (Assignment Sheet 2)
6. Diagnose turn and hazard signal problems. (Assignment Sheet 3)
7. Diagnose back-up light problems. (Assignment Sheet 4)
8. Diagnose brake/collision light problems. (Assignment Sheet 5)
9. Diagnose dash light problems. (Assignment Sheet 6)
10. Diagnose courtesy light problems. (Assignment Sheet 7)

11. Demonstrate the ability to:

    a. Inspect, test, and replace headlights. (Job Sheet 1)

    b. Inspect and service taillight/parking light subsystem. (Job Sheet 2)

    c. Inspect and service turn and hazard signal subsystems. (Job Sheet 3)

    d. Inspect and service back-up light subsystem. (Job Sheet 4)

    e. Inspect and service brake/collision lights. (Job Sheet 5)

    f. Inspect and service dashlight subsystems. (Job Sheet 6)

    g. Inspect and service courtesy light subsystem. (Job Sheet 7)

LIGHTING SYSTEM

PREPARATION

- Review unit and plan presentation.
- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.
- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.
- Review teaching suggestions and plan classroom activities.
- Determine how you will schedule time for students to demonstrate competence in the required procedures.
- Order materials to supplement unit.
- Invite an electrical/electronic repair specialist to speak to the class about lighting system problem diagnosis and service.

  NOTE: Supply guest speakers with the Objective Sheet, Information Sheet and any other components you want them to cover.

DELIVERY

Objective 1 Complete statements about headlight systems.
Objective 2 Match names and descriptions of exterior lighting systems.
Objective 3 Describe interior lighting systems.

- Have students refer to parts catalogs and service manuals to identify subsystems, parts and components in the lighting systems of a variety of cars.
- Have students compare late model to older model lighting system diagrams and discuss differences between the two.
- Have students identify other systems commonly linked with the lighting system (i.e., driver information system, braking system).
- Have students complete Activity Sheet 1.

APPLICATION

Objective 4 Diagnose headlight problems.
Objective 5 Diagnose taillight/parking light problems.
Objective 6 Diagnose turn and hazard signal problems.
Objective 7 Diagnose back-up light problems.
Objective 8 Diagnose brake/collision light problems.
Objective 9 Diagnose dash light problems.
Objective 10 Diagnose courtesy light problems.
Objective 11 Demonstrate the ability to:

- **a. Inspect, test, and replace headlights.**
- **b. Inspect and service taillight/parking light subsystems.**
- **c. Inspect and service turn and hazard signal subsystems.**
- **d. Inspect and service back-up light subsystem.**
- **e. Inspect and service brake/collision lights.**
- **f. Inspect and service dashlight subsystems.**
- **g. Inspect and service courtesy light subsystem.**

- Compare service and troubleshooting charts from various makes and models. Have students note similarities and differences.

- This is a "hands-on" unit. Allow students to test and service a variety of makes and models.

- Use of wiring diagrams and service manuals should be stressed. Students still having difficulty using wiring diagrams may need to review before completing some assignments.

- As students evaluate lighting systems, review of basic electrical circuitry may be necessary. Difference between parallel and series circuits and how faults affect these circuits may need to be discussed.

- Have students complete Assignment Sheets 1-7 and Job Sheets 1-7.

- As assignment and job sheets are completed, compare testing and servicing between subsystems. Students should realize that basic steps in any system are:

  — observe system's operation
  — determine what other systems share circuitry
  — observe connected system's operation

- if fault exists in all connected systems, test and service common circuitry
- if fault exists in only one system, test and service circuitry used by only that system

- Testing is basically for continuity. Opens and grounds are obvious causes of lighting system failure, but high resistance problems are common and often overlooked. As students complete job sheets and practical tests, stress a need to check all grounds for loose connections or corrosion.

EVALUATION

Pretest

- Pretest qualifying students.
- Determine individual requirements from pretest results.
- Counsel students individually on pretest results and study requirements.
- Modify materials in unit or create supplementary materials for individual students as required.

Practical test

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.

- Complete appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Publications

- *Automotive Electrical Systems* (3rd ed). W.E. Billiet and L.F. Goings. Student guide covering basic principles, construction, and operation of electrical systems, including troubleshooting, repair and maintenance for ignitions, regulators, etc. Has assignments, self-check lists, and tests. Order No. 0040-2, available from American Technical Publishers, Inc., phone 1-800-323-3471.

Media

- *Basic Automotive Service*, offered by Vocational Media Associates, Box 1050, Mount Kisco, New York 10549-0050. Part one of this five-part filmstrip or filmstrip-on-video with program guide discusses "Light Bulb Service." The film shows how to remove and replace burned out bulbs and discusses causes of burn-out. Other sections of the series discuss how to keep a car in good running condition.

Computer Software

- *Electrical Systems.* Lessons, quizzes, and teacher guides on each of five areas. *Electrical System* includes basic components, battery, starting system, charging system, circuits in the ignition system, preglow time and afterglow heating. "Starting Systems" discusses the battery, use of the voltmeter, load tests, electrolyte, using shims and marking wires. "Charging Systems" addresses the battery, the alternator, voltage regulator, ammeter, components, alternator defects, and covers electrical problems and causes, problem solving, types of voltage regulators and how to check the belts. "Ignition Systems" takes in components, high-voltage circuits, preglow plugs, controlled afterglow, and how to advance and retard timing in old and new cars and the effects of ignition timing. "Electrical Accessories" shows and discusses the function of various accessories and explains why they must be in good working condition. Two 5¼" disks or 3½" disk for Apple II and IBM-PC with 128K. IBM-PC requires CGA graphics compatibility. Order No. SWE320A for Apple II

Family, SWE3201 for IBM-PC, available from Cambridge Vocational and Technical, phone 1-800-468-4227.

UNIT REFERENCES

- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1985.
- *Auto Electricity, Electronics, Computers.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1990.
- *1988 Celebrity Electrical Diagnosis Service Manual Supplement.* General Motors Corp., Inc., 1988.
- *1990 C/K Pickup Electrical Diagnosis and Wiring Diagrams.* General Motors Corp., Inc., 1989.

PRETEST ANSWERS

LIGHTING SYSTEM

EVALUATOR NOTE

Use the answer key below to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions.

Objective	Question
1	1-4
2	5-12
3	13-15
4	16-17
5	18-19
6	21
7	22
8	25
9	20
10	23-24
11	26-32

ANSWER KEY

1. a
2. c
3. b
4. a
5. c
6. c
7. a
8. b
9. b
10. a
11. b
12. a
13. a
14. c
15. b
16. c
17. a
18. c
19. c
20. b
21. b
22. a
23. c
24. b
25. c
26. a
27. c
28. b

PRETEST

LIGHTING SYSTEM

NAME ______________________ SCORE ________

DIRECTIONS

Choose the answer that best completes the statement. Write the answer in the blank before the statement.

______1. Three types of headlamps are halogen, ___.

a. number 1, and number 2
b. type A, and type B
c. soft white, and multi-filament

______2. The headlight system is made up of a switch, headlights, ___.

a. and wiring only
b. wiring, fuses, and taillights
c. wiring, fuses, a dimmer switch, and the battery

______3. The headlight switch contains an on/off switch, ___.

a. and variable resistor
b. a variable resistor, and a circuit breaker
c. and a circuit breaker

______4. If a car has four headlights, the dimmer switch determines ___.

a. whether two or four headlights are lit
b. how much current runs to all four lights
c. how much resistance is in the circuit

______5. The two common types of turn signal switches are ___.

a. manual and electronic
b. push/pull and lever-type
c. basic switch and multi-purpose switch including horn, dimmer switch and cruise control

______6. Turn signals flash off and on because the flasher unit contains ___.

a. an electronic control device that turns the circuit on and off
b. a diode that only allows one direction of the alternating current
c. a circuit breaker that opens and closes

______7. The hazard light subsystem uses ___.

a. turning signal circuitry
b. park light circuitry
c. headlight and taillight circuitry

______8. Taillights are included in the ___

a. brake light circuit
b. headlight circuit
c. hazard light circuit

______9. The brake light switch is activated by the ___.

a. brake shoe
b. brake pedal
c. transmission

_____10. Brightness of the dash board light is controlled by increasing or decreasing circuit ___.

a. resistance
b. voltage
c. amperage

_____11. Courtesy lights are connected ___.

a. in series with circuits that always receive current
b. in parallel with circuits that always receive current
c. directly to the battery

_____12. Courtesy lights may be controlled by ___.

a. more than one switch
b. the speed of the car and charge of the battery
c. turning on or off the headlight switch

_____13. If only one headlight will not light, check the ___.

a. bulb, socket, and wiring
b. bulb, switch, and socket
c. switch, socket, and wiring

_____14. If headlights flicker, the fault is probably ___.

a. an open
b. a ground
c. high resistance

_____15. If both headlights and taillights fail to operate properly, one should test ___.

a. all bulbs
b. the headlight switch
c. wiring from the headlight switch to each bulb

_____16. If a single taillight fails to operate even though the bulb has been replaced, one should ___.

a. replace the bulb again
b. test the switch
c. test the socket and wiring

_____17. If the hazard flasher is faulty, will turn signals still operate properly?

a. Yes
b. No

_____18. Back up lights should be on when the car is ___.

a. started
b. in park or neutral
c. in reverse only

_____19. If brake lights fail to operate, one should first check ___.

a. all bulbs
b. the switch
c. the fuse

_____20. To help diagnose the cause of dash light problems, one should ___.

a. test the circuit with a voltmeter
b. turn on parking or headlights and vary the dimming switch
c. remove the dash

_____21. If the courtesy fuse is blown, ___.

a. all courtesy lights will still operate
b. no courtesy lights will operate
c. some courtesy lights will operate, others won't

_____22. If courtesy lights come on when the driver's door is opened, but not when the passenger's door is opened, ___.

a. the passenger door switch may be faulty or improperly grounded
b. the courtesy light circuit breaker may be open
c. the power window circuit may be shorting into the driver's door switch

_____23. Headlamps can be removed and tested by ___.

a. testing them with an ammeter
b. putting them in the park lamp socket
c. connecting them to a battery

______24. If an aiming screen is used, the car should be parked ___.

a. as near the screen as possible
b. 25 feet from the screen
c. 40 feet from the screen

______25. When aiming headlights, the procedure should be done with ___.

a. brights on
b. dims on
c. both a and b

______26. When diagnosing a lighting problem, one could ___.

a. first refer to the service manuals and wiring diagrams to locate connected circuits
b. start at the center of the system and trace toward the light
c. start at the light and trace toward the center of the system

______27. If a single system fails to operate properly, one should test ___.

a. all circuitry for all connected systems
b. only the circuitry shared by the affected system and other systems
c. only the circuitry used solely by the affected system

______28. If several connected systems fail to operate, one should test ___.

a. all circuitry for all connected systems
b. only the circuitry shared by the other systems
c. only the circuitry used solely by the affected system

OBJECTIVE 1

Complete statements about headlight systems. (Assignment Sheet 1, Job Sheet 1)

- The headlight system includes the headlamps, light and dimmer switches, a fuse panel, the battery, and wiring. The taillights, instrument lights, and marker lights are also connected in circuit.

  NOTE: If the headlights are concealed, the circuit will also include an electric motor mechanism or vacuum to open and close the flaps.

- The headlight switch contains an on/off switch and a variable resistor (rheostat) that controls the current flow to the bulbs in the instrument panel.

- Three types of bulbs can be used, those with one element high those with two elements high/low and halogen headlamps.

Some automobiles have automatic dimmer systems. These systems detect light from oncoming traffic and automatically switch to low beams, then switch back to high beam when no oncoming light is detected. A small light sensor is located in the grille or on the dash. When the sensor is exposed to light, it produces a small electric current. An amplifier sends the necessary current to operate the dimmer relay from the sensor to the relay, controlling the beam.

OBJECTIVE 2

Match names and descriptions of exterior lighting systems. (Assignment Sheets 2-5, Job Sheets 2-5)

- **Turn signal lights**

  NOTE: The turn signal, hazard, and brake/collision light subsystems are separate, but use much of the same circuitry, including wiring, electrical connections, and light bulbs.

  — Usually consists of turnlights, indicator bulbs, a turnlight switch, flasher unit, fuse, and wiring

  - Two types of turning signal switches are the basic switch and the multi-purpose switch that also includes a horn, dimmer switch, and cruise control. Both are mounted on the steering column.

  - The flasher unit is usually found on the fuse panel or under the dash. It contains a circuit breaker. When contact is made, current flows through the breaker and the turn signal flashes on. As the circuit breaker heats, contact is broken, and the circuit breaker flashes off.

- **Hazard lights**

  - The hazard light subsystem includes the turning signal subsystem, a switch, and a flasher.

  - The hazard switch, usually a push/pull switch on the steering column, sends current to all four turning signals when switched on. When contact is made, current flows through the breaker and the turn signal flashes on. As the circuit breaker heats, contact is broken, and the circuit breaker flashes off.

- **Taillight/parking lights**

  - The taillights are included in the headlight circuit. When headlights are turned on, taillights also come on.

  - Parking lights are also controlled by the headlight switch.

- **Back-up lights**

  - The backup light system includes two backup lamps, a switch, a fuse, and wiring.

  - The backup switch is located on the gear shift in some vehicles and on the transmission in others. When the car is shifted into reverse, the switch is closed, the circuit is completed, and the lamps are lit.

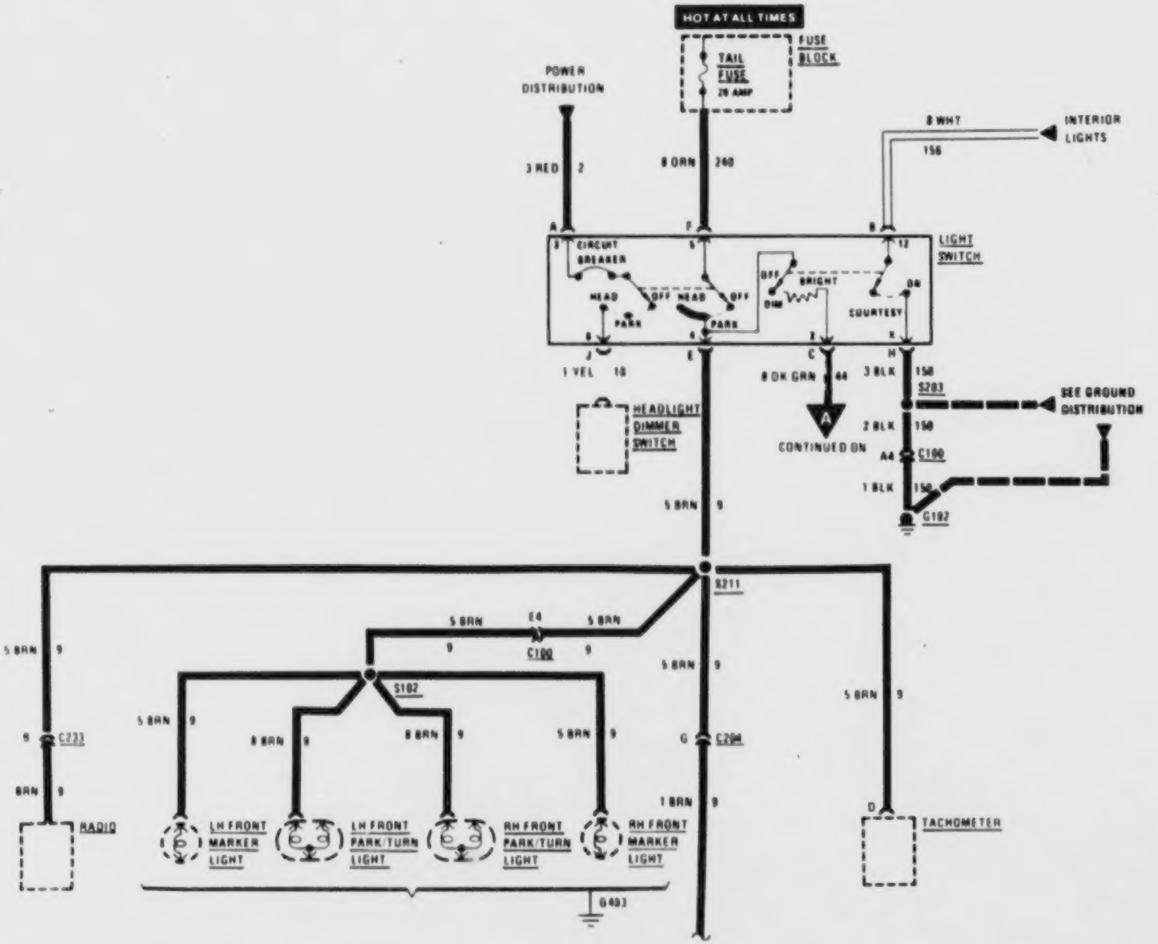
- **Brake/collision lights**

  - The brake/collision system usually includes rear lamps, a brake light switch, a fuse, and wiring.

- — The brake light switch is activated by the brake pedal. Depressing the brake pedal closes the switch, completing the circuit and turning on the brake light.

OBJECTIVE 3 **Describe interior lighting systems. (Assignment Sheets 6 and 7, Job Sheets 6 and 7)**

- **Dash light**
  - — The headlight switch includes a switch controlling current flow to the dash board lights. When the switch is on, current flows through the switch and a rheostat. The rheostat increases or decreases resistance in the circuit, increasing or decreasing the brightness of the dashboard lighting.
- **Courtesy lights**
  - — Courtesy lights include the dome light, trunk light, engine compartment light, glove box light, cigarette lighter and light, reading lights, and other comfort system lights.
  - — Courtesy lights are connected in parallel to circuits that always receive current. Most courtesy lights are controlled by the door-jamb switches, which complete the circuit. On some automobiles, when the switch is closed (as may happen when a door is opened), the circuit becomes powered or grounded and therefore complete.
  - — Some courtesy lights may be controlled by more than one switch. For example, the dome light is controlled by a dome light switch and by the individual door-jamb switches.


HOT AT ALL TIMES
FUSE BLOCK
TAIL FUSE
20 AMP
POWER DISTRIBUTION
3 RED 2
8 ORN 240
8 WHT
156
INTERIOR LIGHTS
A
F
B
3
5
12
CIRCUIT BREAKER
HEAD
PARK
OFF
HEAD
OFF
PARK
OFF
BRIGHT
DIM
COURTESY
ON
LIGHT SWITCH
6
4
2
X
J
E
C
H
1 YEL 10
8 DK GRN 44
A
CONTINUED ON
3 BLK 150
S203
SEE GROUND DISTRIBUTION
2 BLK 150
A4
C100
1 BLK 150
G102
HEADLIGHT DIMMER SWITCH
5 BRN 9
S211
5 BRN
E4
5 BRN
9
C100
9
5 BRN 9
S102
5 BRN 9
8 BRN 9
8 BRN 9
5 BRN 9
5 BRN 9
5 BRN 9
B
C233
BRN 9
G
C204
1 BRN 9
D
RADIO
LH FRONT MARKER LIGHT
LH FRONT PARK/TURN LIGHT
RH FRONT PARK/TURN LIGHT
RH FRONT MARKER LIGHT
TACHOMETER
G403

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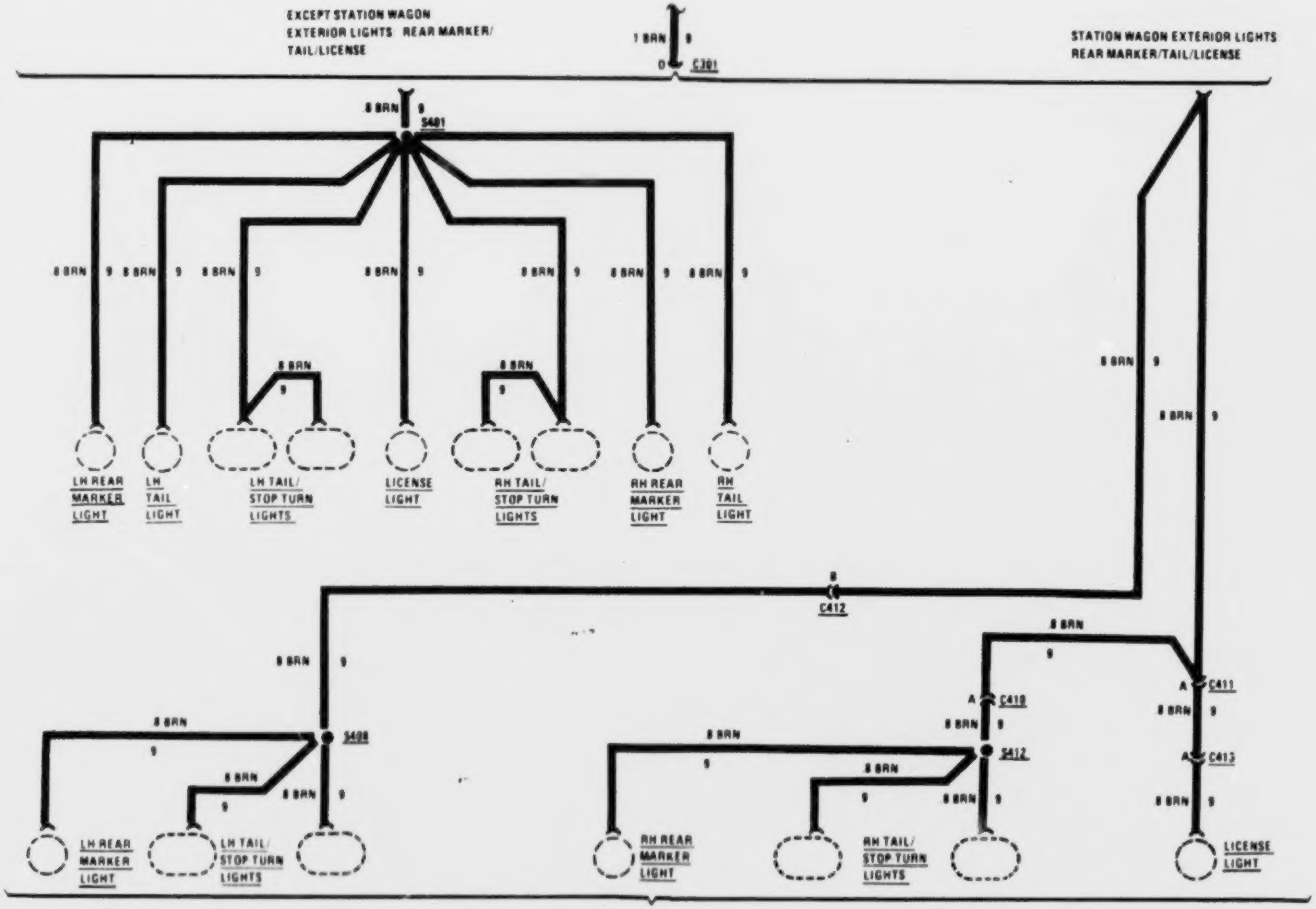
EXCEPT STATION WAGON
EXTERIOR LIGHTS REAR MARKER/
TAIL/LICENSE
1 BRN 9
D C301
STATION WAGON EXTERIOR LIGHTS
REAR MARKER/TAIL/LICENSE
8 BRN 9
S401
8 BRN 9
8 BRN
9
LH REAR
MARKER
LIGHT
LH
TAIL
LIGHT
LH TAIL/
STOP TURN
LIGHTS
LICENSE
LIGHT
RH TAIL/
STOP TURN
LIGHTS
RH REAR
MARKER
LIGHT
RH
TAIL
LIGHT
8
C412
S408
A C410
A C411
A C413
S412
LH REAR
MARKER
LIGHT
LH TAIL/
STOP TURN
LIGHTS
RH REAR
MARKER
LIGHT
RH TAIL/
STOP TURN
LIGHTS
LICENSE
LIGHT

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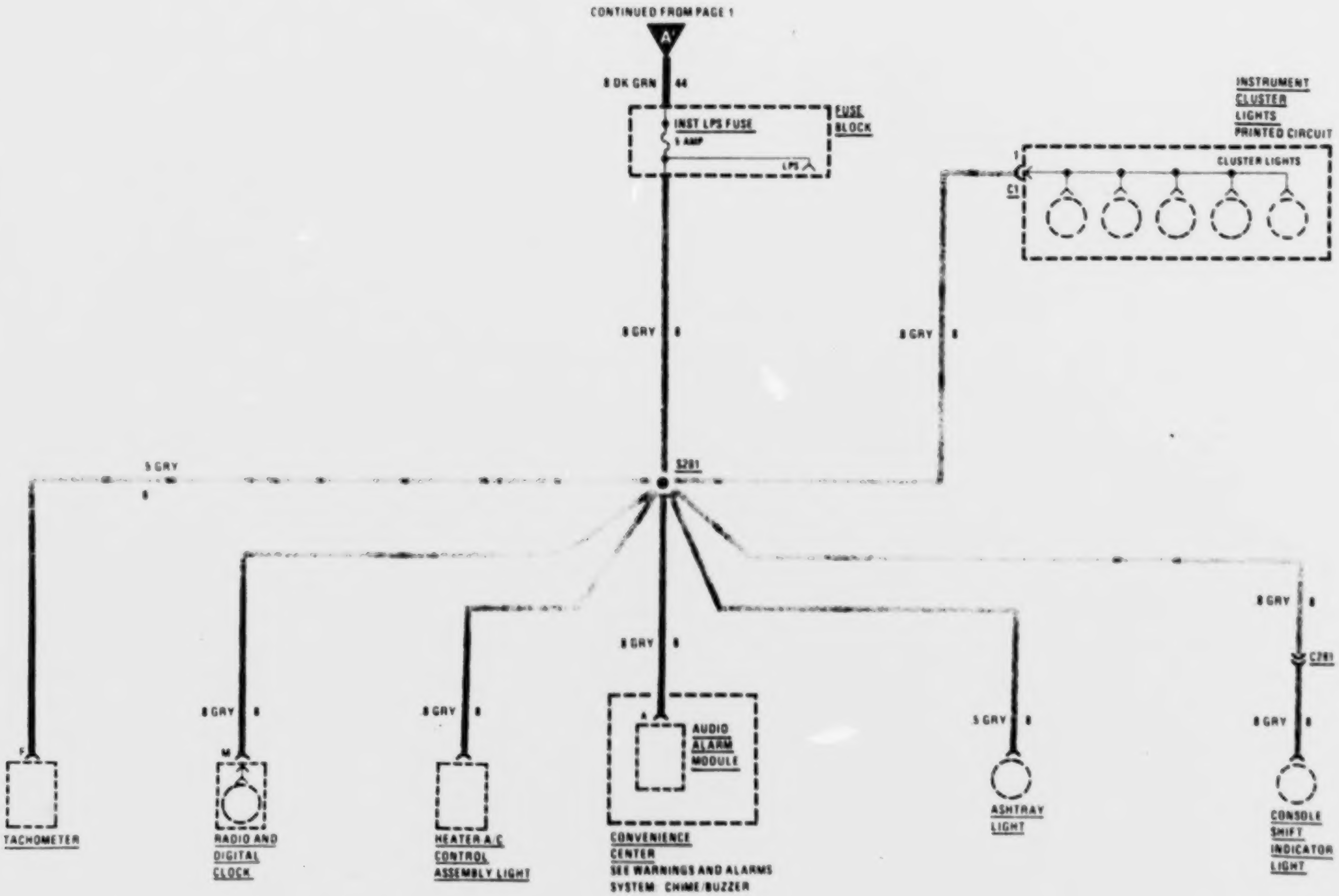
CONTINUED FROM PAGE 1
A'
8 DK GRN 44
INST LPS FUSE
5 AMP
LPS
FUSE
BLOCK
8 GRY 8
INSTRUMENT
CLUSTER
LIGHTS
PRINTED CIRCUIT
1
C1
CLUSTER LIGHTS
8 GRY 8
5 GRY
8
S201
F
TACHOMETER
8 GRY 8
M
RADIO AND
DIGITAL
CLOCK
8 GRY 8
HEATER A/C
CONTROL
ASSEMBLY LIGHT
8 GRY 8
A
AUDIO
ALARM
MODULE
CONVENIENCE
CENTER
SEE WARNINGS AND ALARMS
SYSTEM CHIME/BUZZER
5 GRY 8
ASHTRAY
LIGHT
8 GRY 8
C201
8 GRY 8
CONSOLE
SHIFT
INDICATOR
LIGHT

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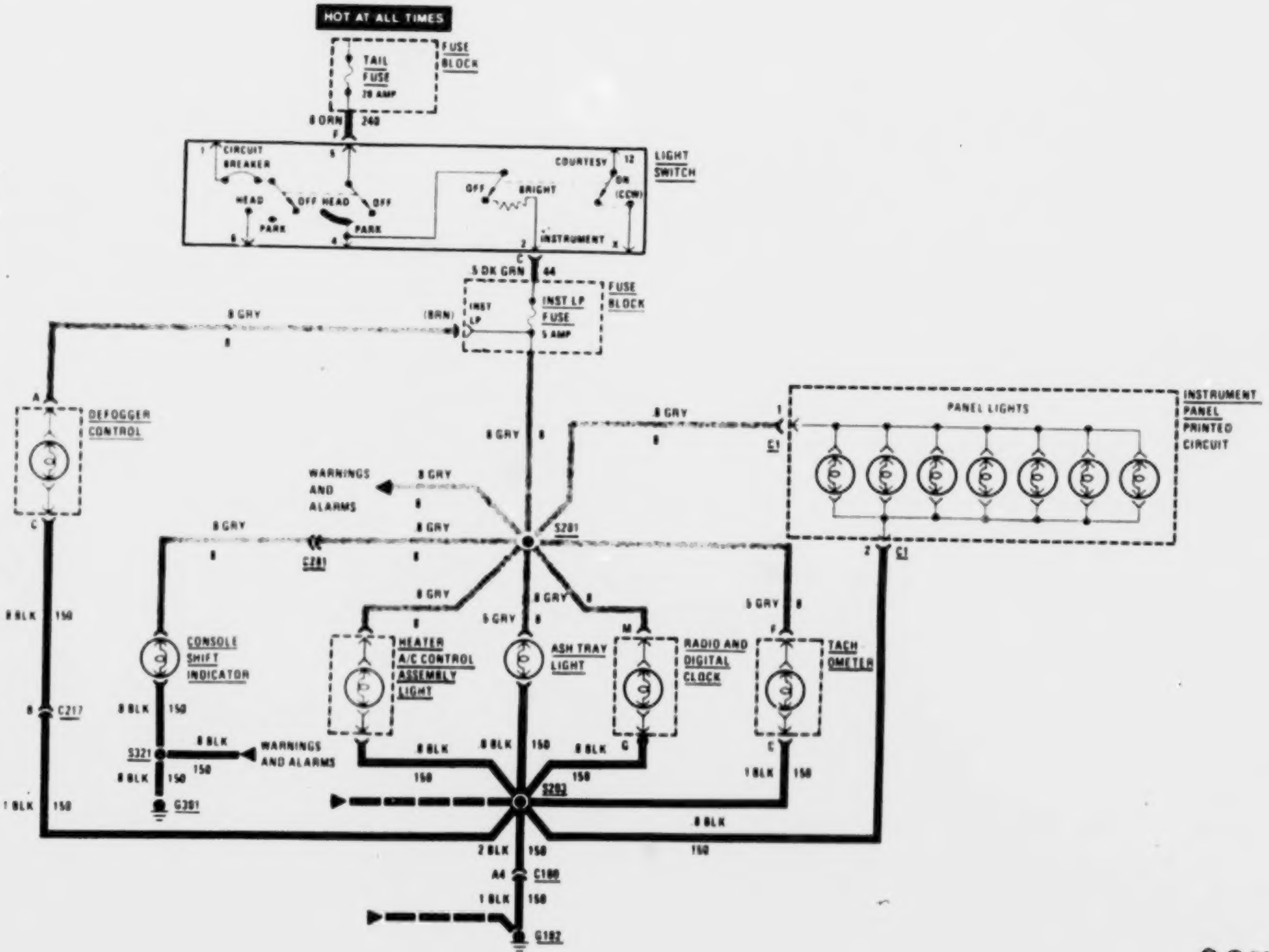
HOT AT ALL TIMES
TAIL FUSE
20 AMP
FUSE BLOCK
8 ORN
240
F
1
CIRCUIT BREAKER
5
HEAD
OFF
HEAD
OFF
PARK
PARK
6
4
OFF
BRIGHT
COURTESY
12
ON (CCW)
2
INSTRUMENT
X
LIGHT SWITCH
C
5 DK GRN
44
INST LP
(BRN)
INST LP FUSE
5 AMP
FUSE BLOCK
8 GRY
8
A
DEFOGGER CONTROL
C
8 BLK
150
B
C217
1 BLK
150
WARNINGS AND ALARMS
8 GRY
8
S201
C281
CONSOLE SHIFT INDICATOR
8 BLK
150
S321
WARNINGS AND ALARMS
G301
HEATER A/C CONTROL ASSEMBLY LIGHT
5 GRY
ASH TRAY LIGHT
M
RADIO AND DIGITAL CLOCK
G
F
TACH OMETER
C
1
C1
PANEL LIGHTS
INSTRUMENT PANEL PRINTED CIRCUIT
2
C1
S202
2 BLK
A4
C100
G102

TROUBLESHOOTING CHART—FRONT EXTERIOR LAMPS

TURN SIGNALS DO NOT WORK ON ONE SIDE

TEST	RESULT	ACTION
1 Turn hazard warning system ON Observe lights on side of turn signals that did not work	Lights flash	CHECK for improper bulb REPLACE if necessary
	Lights do not come on	GO to step 2
2 Turn hazard warning system off Place ignition switch to RUN and turn signal to side that does not work Connect test lamp from LT BLU (14) or DK BLU (15) wire (depending on which side does not work) at directional signal switch connector C206 to ground	Test lamp lights	GO to step 4
	Test lamp does not light	GO to step 3
3 Connect test lamp from PPL (16) at directional signal switch connector C206 to ground	Test lamp lights	REPLACE directional signal switch
	Test lamp does not light	REPLACE turn signal flasher
4 Connect test lamp from LT BLU (14) or DK BLU (15) wire (depending on which side did not work) at park lamp connector C105 or C106 to ground	Test lamp lights	GO to step 5
	Test lamp does not light	LOCATE and REPAIR open in either LT BLU (14) or DK BLU (15) wires
5 Connect test lamp from LT BLU (14) or DK BLU (15) wire to BLK (150 or 151) wire at park lamp C105 or C106	Test lamp lights	CHECK condition of bulb sockets
	Test lamp does not light	LOCATE and REPAIR open in BLK (150 or 151) wire

TURN SIGNALS DO NOT OPERATE

TEST	RESULT	ACTION
1. Place hazard warning lamps to ON position	Hazard lights operate	GO to step 2
	Hazard lights do not operate	GO to step 3
2. Connect a test lamp from PPL (16) wire at directional signal switch connector C206 to ground	Test lamp lights	REPLACE directional signal switch
	Test lamp does not light	CHECK condition of fuse (TURN/BU) and an open in PPL (16) wire, DK BLU (38) wire, or BLK (150) wire. If fuse and wiring are good, REPLACE turn signal flasher
3. Place ignition switch in RUN position and put turn signal switch as if making a left turn. Connect test lamp from LT BLU (14) wire at directional signal switch connector C206 to ground	Test lamp flashes	LOCATE and REPAIR open in wires from turn signal switch to convenience center
	Test lamp does not light	REPLACE directional signal switch

TURN SIGNAL LAMPS FLASH RAPIDLY

TEST	RESULT	ACTION
Turn hazard lamp switch ON. Check front signal lamps and rear taillamps	One side of turn signal lamps flash rapidly	REPLACE inoperative turn signal bulb
	Only one side of turn signals light but do not flash rapidly	REFER to "Turn Signals Do Not Operate On One Side" symptom

HAZARD WARNING LAMPS DO NOT OPERATE

TEST	RESULT	ACTION
1. Place ignition switch in RUN and position turn signal lamps as if making a turn.	Turn signal lights operate	GO to step 2
	Turn signal lights do not operate	GO to step 3
2. Turn off turn signal lamps and put hazard warning lamps ON. Connect a test lamp from BRN (27) wire at directional signal switch connector C206 to ground.	Test lamp lights.	REPLACE directional signal switch
	Test lamp does not light	CHECK condition of fuse (STOP/HAZ) and an open in ORN (140) wire and BRN (27) wire. If fuse and wiring are good. REPLACE hazard flasher
3. Place hazard lamps ON. Connect test lamp from LT BLU (14) wire at directional signal switch connector C206 to ground	Test lamp flashes	LOCATE and REPAIR open in wires from directional signal switch to convenience center
	Test lamp does not light	REPLACE directional signal switch

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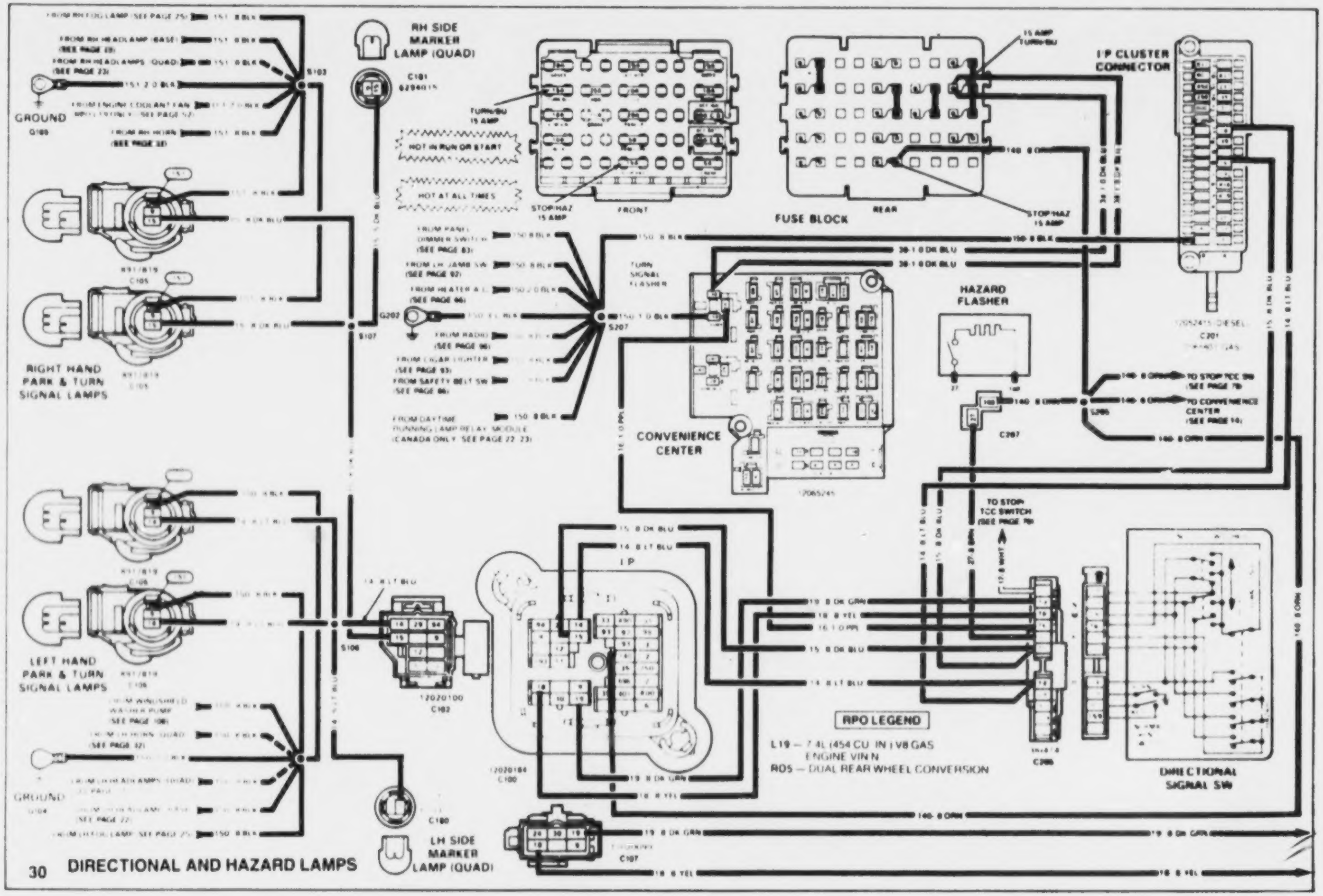
RH SIDE MARKER LAMP (QUAD)
C101
GROUND
G100
S103
RIGHT HAND PARK & TURN SIGNAL LAMPS
HOT IN RUN OR START
HOT AT ALL TIMES
TURN/BU 15 AMP
STOP/HAZ 15 AMP
FRONT
REAR
FUSE BLOCK
15 AMP TURN/BU
I/P CLUSTER CONNECTOR
FROM PANEL DIMMER SWITCH (SEE PAGE 83)
FROM LH JAMB SW (SEE PAGE 92)
FROM HEATER A/C (SEE PAGE 96)
FROM RADIO (SEE PAGE 96)
FROM CIGAR LIGHTER (SEE PAGE 93)
FROM SAFETY BELT SW (SEE PAGE 84)
FROM DAYTIME RUNNING LAMP RELAY MODULE (CANADA ONLY, SEE PAGE 22, 23)
G202
S107
S207
TURN SIGNAL FLASHER
150 .8 BLK
38-1.0 DK BLU
HAZARD FLASHER
CONVENIENCE CENTER
C201
S205
C207
TO STOP/TCC SW (SEE PAGE 79)
TO CONVENIENCE CENTER (SEE PAGE 10)
140 .8 ORN
TO STOP/TCC SWITCH (SEE PAGE 79)
I/P
15 .8 DK BLU
14 .8 LT BLU
19 .8 DK GRN
18 .8 YEL
16 1.0 PPL
27 .8 GRY
17 .8 WHT
C102
S106
LEFT HAND PARK & TURN SIGNAL LAMPS
GROUND
G104
C100
RPO LEGEND
L19 — 7.4L (454 CU. IN.) V8 GAS ENGINE VIN N
R05 — DUAL REAR WHEEL CONVERSION
C206
DIRECTIONAL SIGNAL SW
C180
LH SIDE MARKER LAMP (QUAD)
C107

30 DIRECTIONAL AND HAZARD LAMPS

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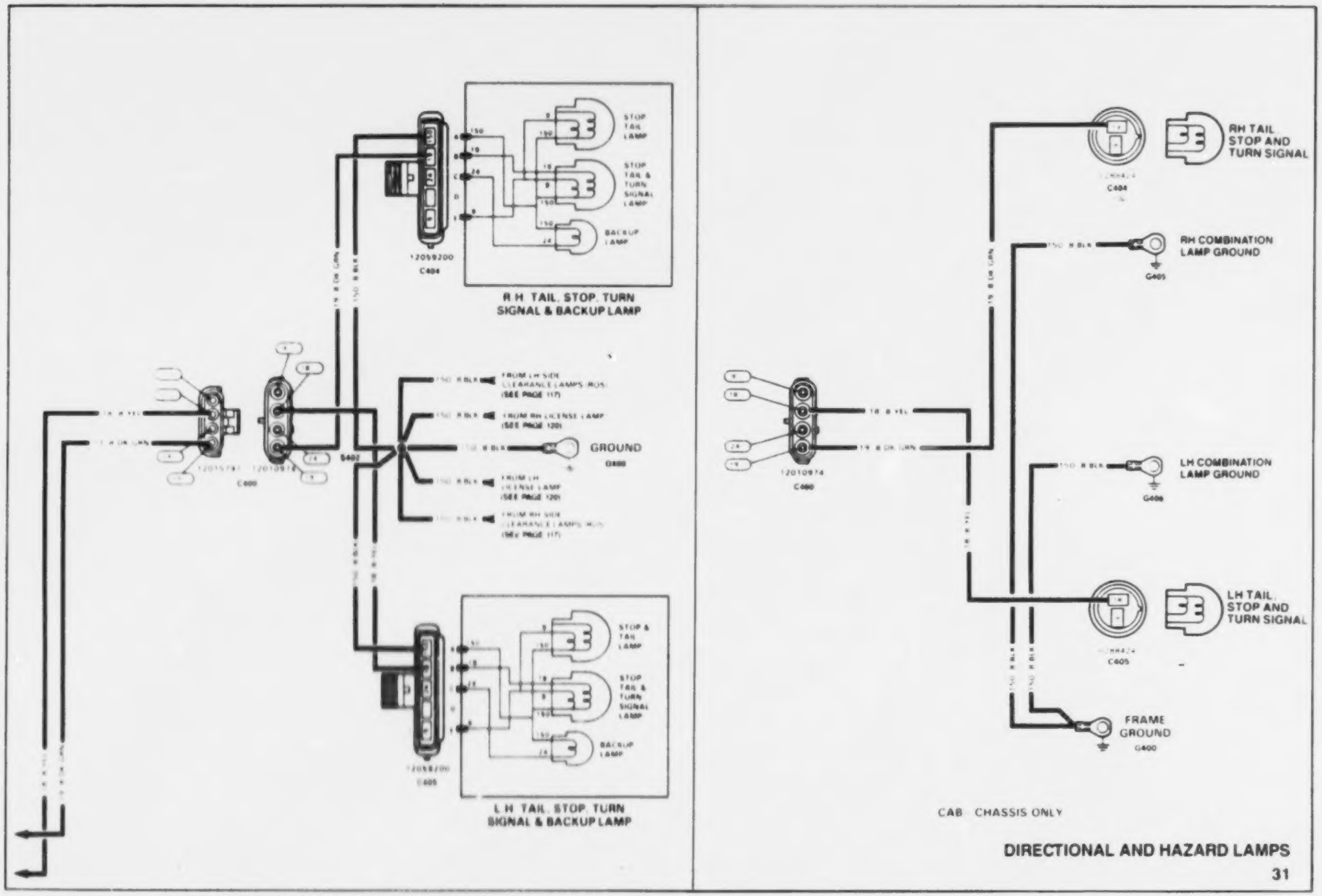
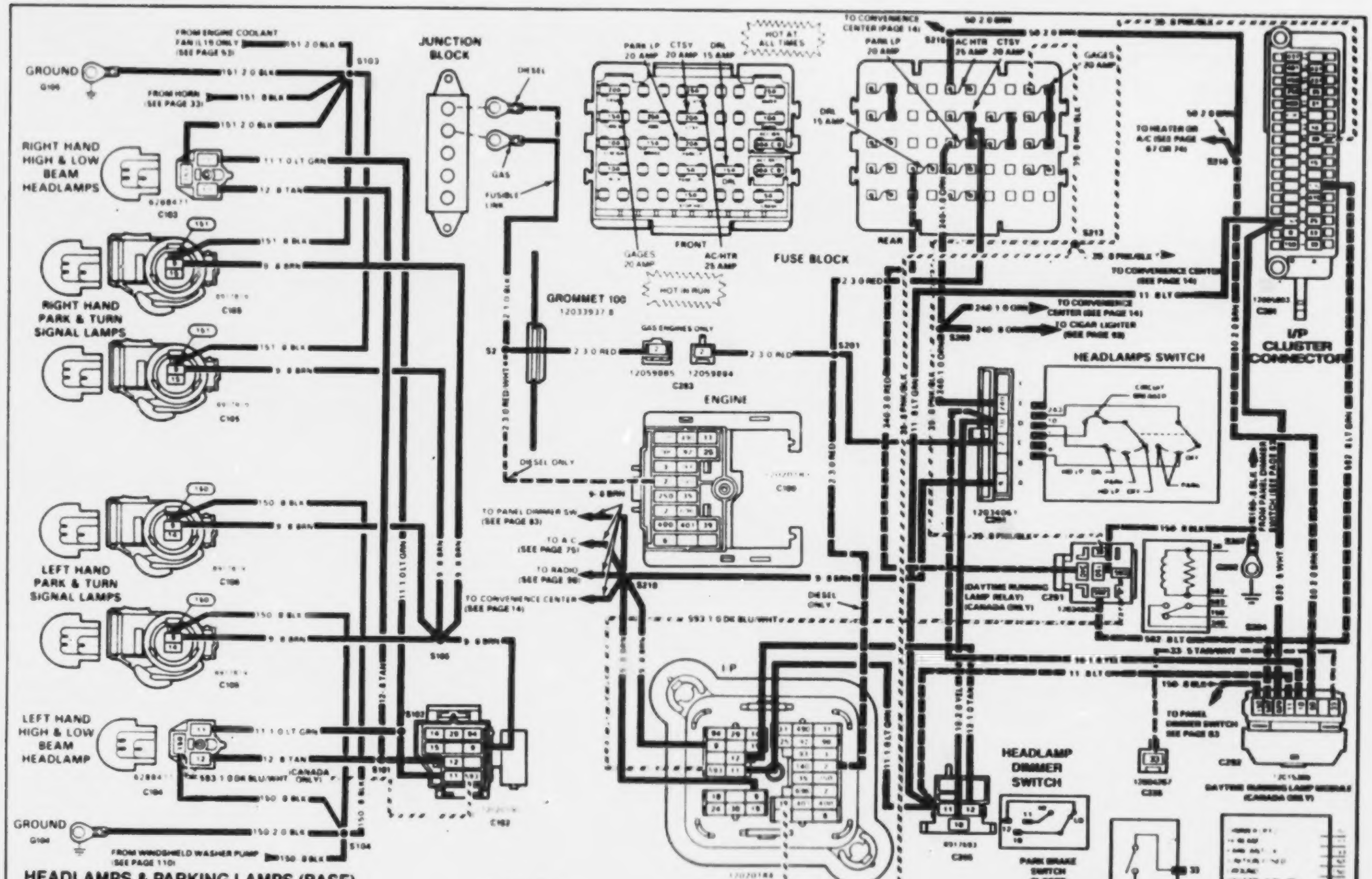

12059200
C404
STOP TAIL LAMP
STOP TAIL & TURN SIGNAL LAMP
BACKUP LAMP
R.H. TAIL, STOP, TURN SIGNAL & BACKUP LAMP
FROM LH SIDE CLEARANCE LAMPS (ROS)
(SEE PAGE 117)
FROM RH LICENSE LAMP
(SEE PAGE 120)
GROUND
G400
FROM LH LICENSE LAMP
(SEE PAGE 120)
FROM RH SIDE CLEARANCE LAMPS (ROS)
(SEE PAGE 117)
S402
12015791
12010973
C400
12059200
C405
STOP & TAIL LAMP
STOP TAIL & TURN SIGNAL LAMP
BACKUP LAMP
L.H. TAIL, STOP, TURN SIGNAL & BACKUP LAMP
12010974
C400
C404
RH TAIL STOP AND TURN SIGNAL
RH COMBINATION LAMP GROUND
G405
LH COMBINATION LAMP GROUND
G406
C405
LH TAIL STOP AND TURN SIGNAL
FRAME GROUND
G400
CAB CHASSIS ONLY

DIRECTIONAL AND HAZARD LAMPS


FROM ENGINE COOLANT FAN (L19 ONLY) (SEE PAGE 53)
GROUND
G105
FROM HORN (SEE PAGE 33)
S103
RIGHT HAND HIGH & LOW BEAM HEADLAMPS
C103
RIGHT HAND PARK & TURN SIGNAL LAMPS
C105
JUNCTION BLOCK
DIESEL
GAS
FUSIBLE LINK
GROMMET 100
GAS ENGINES ONLY
C283
ENGINE
C100
HOT AT ALL TIMES
PARK LP 20 AMP
CTSY 20 AMP
DRL 15 AMP
FRONT
GAGES 20 AMP
AC/HTR 25 AMP
HOT IN RUN
FUSE BLOCK
TO CONVENIENCE CENTER (PAGE 14)
REAR
TO HEATER OR A/C (SEE PAGE 67 OR 74)
TO CONVENIENCE CENTER (SEE PAGE 14)
TO CIGAR LIGHTER (SEE PAGE 63)
I/P CLUSTER CONNECTOR
HEADLAMPS SWITCH
TO PANEL DIMMER SW (SEE PAGE 83)
TO A/C (SEE PAGE 75)
TO RADIO (SEE PAGE 96)
TO CONVENIENCE CENTER (SEE PAGE 14)
S210
DIESEL ONLY
DAYTIME RUNNING LAMP RELAY (CANADA ONLY)
LEFT HAND PARK & TURN SIGNAL LAMPS
C106
S100
I P
LEFT HAND HIGH & LOW BEAM HEADLAMP
C104
C102
S104
GROUND
G104
FROM WINDSHIELD WASHER PUMP (SEE PAGE 110)
HEADLAMP DIMMER SWITCH
C205
PARK BRAKE SWITCH CLOSED WITH PARK BRAKE ON
TO PANEL DIMMER SWITCH SEE PAGE 83
DAYTIME RUNNING LAMP MODULE (CANADA ONLY)

HEADLAMPS & PARKING LAMPS (BASE)

22

RPO LEGEND

L19 — 7.4L (454 CU. IN.) V8 GAS ENGINE VIN N

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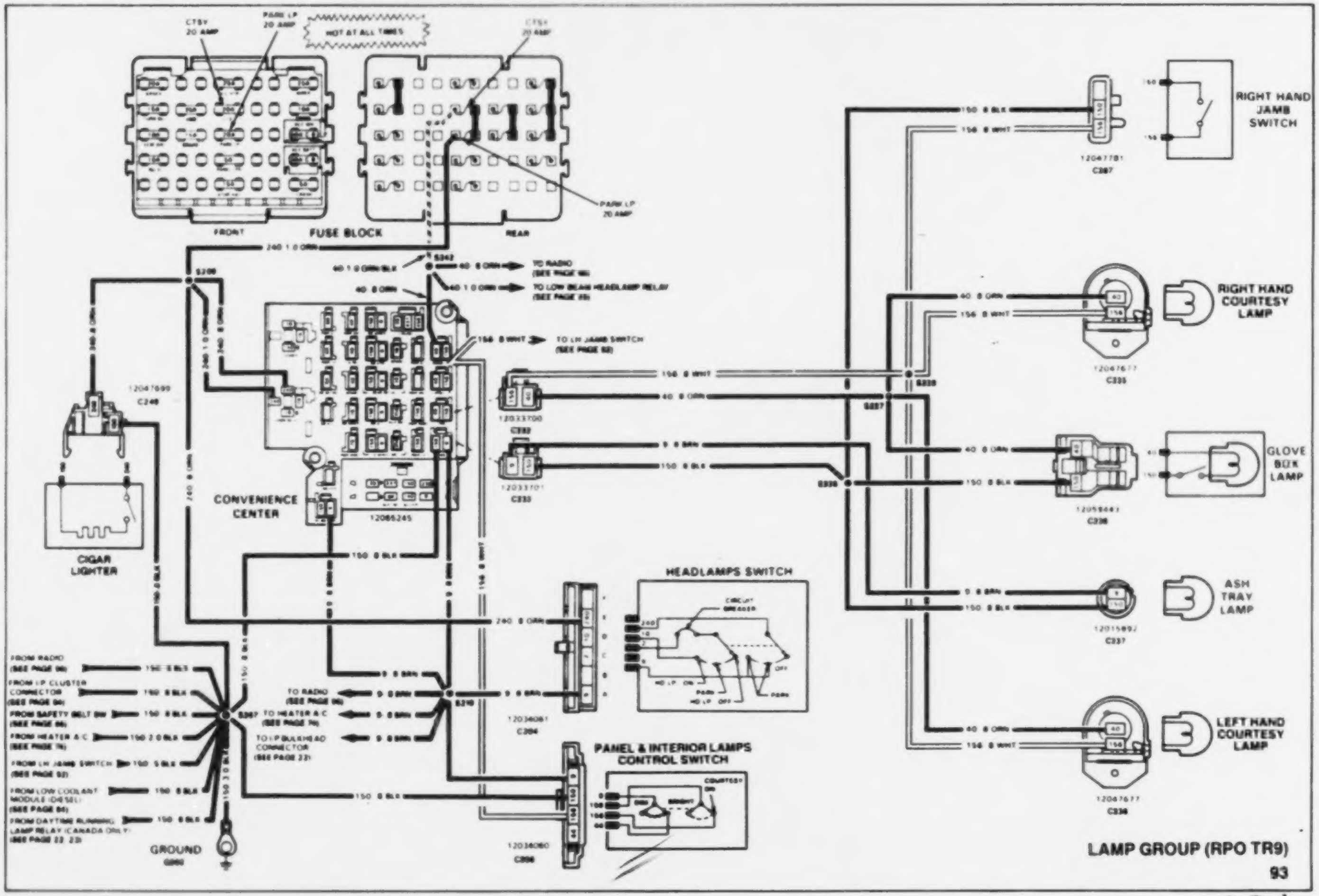
CTSY 20 AMP
PARK LP 20 AMP
HOT AT ALL TIMES
CTSY 20 AMP
FRONT
FUSE BLOCK
REAR
PARK LP 20 AMP
240 1.0 ORN
S206
S242
40 1.0 ORN/BLK
40 .8 ORN
TO RADIO (SEE PAGE 96)
40 1.0 ORN
TO LOW BEAM HEADLAMP RELAY (SEE PAGE 25)
40 .8 ORN
156 .8 WHT
TO LH JAMB SWITCH (SEE PAGE 92)
12047699
C248
CIGAR LIGHTER
CONVENIENCE CENTER
12085245
12033700
C232
12033701
C233
150 .8 BLK
156 .8 WHT
40 .8 ORN
9 .8 BRN
S238
S237
S236
12047781
C387
RIGHT HAND JAMB SWITCH
RIGHT HAND COURTESY LAMP
12047677
C235
GLOVE BOX LAMP
12059443
C236
ASH TRAY LAMP
12015892
C237
LEFT HAND COURTESY LAMP
12047677
C238
HEADLAMPS SWITCH
CIRCUIT BREAKER
HD LP ON
PARK
HD LP OFF
OFF
240 .8 ORN
12034061
C204
PANEL & INTERIOR LAMPS CONTROL SWITCH
COURTESY ON
DIM
BRIGHT
12034060
C208
FROM RADIO (SEE PAGE 96)
FROM I.P. CLUSTER CONNECTOR (SEE PAGE 94)
FROM SAFETY BELT SW (SEE PAGE 86)
FROM HEATER A/C (SEE PAGE 76)
FROM LH JAMB SWITCH (SEE PAGE 92)
FROM LOW COOLANT MODULE (DIESEL) (SEE PAGE 84)
FROM DAYTIME RUNNING LAMP RELAY (CANADA ONLY) (SEE PAGE 22, 23)
150 .8 BLK
150 2.0 BLK
150 3.0 BLK
S207
GROUND
G200
TO RADIO (SEE PAGE 96)
TO HEATER A/C (SEE PAGE 76)
TO I.P. BULKHEAD CONNECTOR (SEE PAGE 22)
9 .8 BRN
S210

LAMP GROUP (RPO TR9)

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CLASS PROJECTS FOR DESIGNING A LIGHT SYSTEM

MAKE A WIRING DIAGRAM FOR AN AUTOMOBILE

Without referring to the service manual, diagram what you think is an automobile's lighting wiring system. Include all loads and circuit protection devices. Decide on their most likely location. Compare your estimated diagram to the actual diagram found in the service manual.

MAKE A WIRING DIAGRAM FOR AN IMAGINARY AUTOMOBILE

In previous units, the option of describing a car of the future or ultimate car has been listed as an activity. Choose one of these imaginary cars and diagram the light system this vehicle would need.

DESIGN THE FANTASY LIGHTING SYSTEM

Choose a fantasy car, such as the Batmobile, or that sweet little sports car of your dreams. List the lighting subsystems included in the car and describe how they would operate.

ASSIGNMENT SHEET 1

LIGHTING SYSTEM

V

NAME ______________________________ SCORE ________

OBJECTIVE 4

Diagnose headlight problems.

INTRODUCTION

Headlights are among the most important lighting subsystems. Improper headlight operation is dangerous and may be illegal. Like other lights, headlight problems may stem from burned out bulbs, faulty bulb sockets, or circuit faults. Headlights must also be properly aimed. In any situation, understanding how the circuit operates will make servicing faster and more accurate.

DIRECTIONS

1. In each of the situations on the following page, determine what you believe may be the cause of the problem. Do not consult a service manual.
2. Write your answer in the first column. Show your work to your instructor.
3. When you have completed the first column, consult a service manual. Write the cause of the problem listed in the service manual in the second column.
4. Compare the two lists. Write the number of correct diagnoses in the blank provided.

Situation	My diagnosis	Service manual diagnosis
1. One headlight does not light		
2. No headlights light		
3. Low beams do not operate on either light		
4. Headlights flicker		

Number of correct diagnoses__________

Manual used ____

____

Page number ____________

ASSIGNMENT SHEET 2

LIGHTING SYSTEM

NAME ______________________________ SCORE ________

OBJECTIVE 5

Diagnose taillight/parking light problems.

INTRODUCTION

The taillights and parking lights are the major rear end lights. They are usually connected in circuit with other rear end lights such as the license tag light, trunk courtesy light and end-gate lamps. They are also connected in circuit with the headlights and are controlled by the headlight switch. When diagnosing problems in this system, it is important to consider all the systems operating with it.

DIRECTIONS

Use the wiring diagram in Supplement 1 and your knowledge of electrical circuitry to answer the following questions.

1. If the tail fuse blows, which rear end lights will continue to operate?

2. If G403 is dirty or loose, what symptoms will appear?

3. If a ground occurs at C204, will the front lights continue to function properly? __________ Will the rear lights? __________ Why or why not?

4. If front and rear lights both fail to operate properly, what component should be tested and serviced?

5. If the right taillight works, but the left taillight fails to operate, should wiring at S401 be checked? Why or why not?

____

____

6. If the right rear parking light fails to light and the bulb has been replaced, name two other possible causes of the problem.

____

____

____

____

ASSIGNMENT SHEET 3

LIGHTING SYSTEM

V

NAME ______________________________ SCORE ________

OBJECTIVE 6

Diagnose turn and hazard signal problems.

INTRODUCTION

The turn signals and hazard lights operate much differently than other lighting systems. When the turn signal switch is activated, voltage is sent to the front and rear lights on the side indicated. The lights come on immediately. However, the current flows through a flasher unit which contains a circuit breaker. As the bimetal strip heats, the circuit is broken. The strip quickly cools, and contact is made again. This is how the lights flash on and off. The hazard lights use the same circuit, however, when the hazard light switch is operated, the circuit to all four flashers is completed. Turn signal indicators and markers also flash when the hazard switch is operated.

DIRECTIONS

Use the troubleshooting chart and wiring diagram in Supplements 3 and 4 to answer the questions below.

1. If the hazard warning lamps fail to operate, and the turn signals do operate, the first test should be ______________

   ____

2. If a test lamp connected to LT BLU (14) at directional signal switch connector C206 indicates an open, will the lamp be lit, flash, or remain unlit? ______________________

   ____

3. If a test lamp connected to PPL16 at the directional signal switch connector C206 does not light, which should be replaced, the directional signal switch or turn signal flasher?

   ____

4. If the hazard flasher is faulty, will turning signals still operate properly? ______________________________

   ____

5. If a bulb is burned out, will trying to operate the light as a turning signal and then as a hazard light help diagnose the problem? ______________________________

____

6. If turn signals do not work on one side because of an open in BLK 150, do the right turn signals work? ______________

____

ASSIGNMENT SHEET 4

LIGHTING SYSTEM

V

NAME ____________________ SCORE ________

OBJECTIVE 7

Diagnose back-up light problems.

INTRODUCTION

Back-up lights are controlled by a switch connected to the gear shift or transmission. When the car is put in reverse, the circuit is closed and back-up lights are lit. Like headlights, the purpose of the back-up light is not just to be seen, but to allow the driver to see the road. Unlike most other lights, it is not controlled by the headlight switch.

DIRECTIONS

1. Read the paragraph below discussing the back-up lighting system.

2. Using the information in the paragraph, complete the troubleshooting chart on the next page.

   Back-up lights should be off when the ignition switch is ON and the car is in park or neutral, but should be on if the ignition is in ON and the car is in reverse. A faulty turn/backup fuse, a misadjusted switch, or a bad ground may prevent the back-up lights from working. A burned-out bulb, faulty socket, or wiring fault may cause one light to go out while the other works properly. If the lights come on in the wrong gear, the connector from the automatic transaxle transmission selector switch or from the back-up lights switch should be disconnected. If the back-up lights go out after the disconnection, the switch should be adjusted or replaced. If they remain lit, a short is indicated.

SYMPTOM	CAUSE	ACTION
Back-up lights do not work.		
One light out—one works		
Lights on in park or neutral		

ASSIGNMENT SHEET 5

LIGHTING SYSTEM

V

NAME ______________________________ SCORE ________

OBJECTIVE 8

Diagnose brake/collision light problems.

INTRODUCTION

The brake/collision lights use much of the turning light circuit. They are controlled, however, by a switch activated by the brake pedal. When the brake is depressed, the circuit is completed and the lights turn on. When the brake is released, the circuit is open and the lights go off. In diagnosing a brake/collision light problem, the question is basically one of determining whether the trouble is actually in the brake/collision switch or in the turning light circuits.

DIRECTIONS

light circuits to answer the questions below.
Use your understanding of the brake/collision and taillight/turning

1. If brake lights do not operate when the ignition is in ON and the brake pedal is depressed, what is the next logical thing to check?

   ____

2. If brake lights do not operate, could the hazard switch assembly need to be replaced?

   ____

3. If brake lights do not operate, could the back-up light switch need to be replaced?

   ____

4. If the problem is a burned out bulb, will the bulb operate when it is used as a turning signal?

   ____

5. If the problem is limited to the brake/collision light system, could the problem be a ground?

   ____

ASSIGNMENT SHEET 6

LIGHTING SYSTEM

V

NAME ______________________________ SCORE ________

OBJECTIVE 9

Diagnose dash light problems.

INTRODUCTION

Three situations can exist when dash light problems occur: all dash lights can fail to operate properly; some dash lights can fail to operate properly while others are not affected; or only one dash light can malfunction. If all dash lights fail to operate properly, a circuit-wide problem such as a faulty switch or fault in a major wire is indicated. If some lights operate properly while others do not, a wiring diagram should be consulted and common circuitry checked. If only one light is affected, the bulb, bulb socket, or wiring to the individual light may be at fault.

DIRECTIONS

Use the wiring diagram in Supplement 2 to determine the correct answer. Write "all" if the test should be used when all lights fail to work properly, "some" if the test should be used when some lights function properly but others don't, and write "one" if the test should be used when only one light fails to function properly.

1. Observe park lights.

   ____

2. Check the grey wire 8 between S201 and the Heater/AC Control Assembly light with a test lamp.

   ____

3. Turn dimmer switch to see if it varies the brilliance of the interior lights.

   ____

4. Check INST LP fuse by using a jumper wire to "jump" the fuse block.

   ____

5. Check grey wire 8 between S201 and the instrument panel printed circuit.

   ____

6. After cleaning a bulb socket for corrosion, a test lamp is grounded and the test light probe is brought into contact with the center terminal of the socket.

____

ASSIGNMENT SHEET 7

LIGHTING SYSTEM

V

NAME ______________________ SCORE ________

OBJECTIVE 10

Diagnose courtesy light problems.

INTRODUCTION

"Courtesy lights" refers to a wide range of lights found in various makes and models. The most common courtesy lights are the dome light, reading lights, glove compartment light, and cigarette light. These are comfort features that do not add to the function or safety of the car, but are expected by the public. Some, like the glove compartment light, are controlled by their own switch. Others may be controlled by any one of several switches. For example, the dome light may be operated by it's own on/off switch, by opening any door, or by the headlight switch in many cars. Although the headlight switch may be used to operate some courtesy lights, it is not necessarily a part of the courtesy light system.

DIRECTIONS

In each of the cases below, use the wiring diagram in Supplement 5 to determine how the fault would affect the system.

1. Blown courtesy fuse

   ____

2. Short wire 150 to 156

   ____

3. Ground at S209

   ____

4. Courtesy light switch left open

   ____

5. Poor ground connection at right front door jamb switch

   ____

ASSIGNMENT ANSWERS

LIGHTING SYSTEM

V

ASSIGNMENT SHEET 1

- Check that all sections of the chart have been completed.

- Compare estimated and service manual diagnoses. Students may diagnose the situation properly and not read the manual properly.

- The grade should reflect three things: understanding of the circuits, ability to read manual properly, and ability to make correct diagnoses.

Likely diagnoses are:

1. Burned out bulb
   Faulty socket
   Wiring fault
2. Wiring fault
   Faulty switch
3. Wiring fault
   Faulty headlight
   Faulty dimmer switch
4. Wiring fault (most likely ground or circuit breaker)

ASSIGNMENT SHEET 2

1. Turn signals
2. All rear lights will work intermittently or not at all.
3. Yes
   No
   The front and rear lights are parallel circuits. A fault at C204 will not affect anything before it, including the front lights.
4. The (head)light switch, power distribution
5. No
   A fault at S401 would affect all rear lights. A more likely diagnosis is a faulty bulb, bulb socket, or wiring to the individual light.
6. Faulty bulb socket
   Faulted wiring to the individual lamp
   Poor ground

ASSIGNMENT SHEET 3

1. Power at the hazard flasher
2. Remain unlit
3. Flasher
4. Yes
5. Yes
6. Yes

ASSIGNMENT SHEET 4

SYMPTOM	CAUSE	ACTION
Back-up lights do not work.	Faulty turn/backup fuse	Replace fuse
	Bad ground	Locate grounds; tighten or clean
	Misadjusted switch	Adjust switch
One light out—one works	Burned-out bulb	Replace bulb
	Faulty socket	Clean socket, test for continuity, replace
	Wiring	Test wiring to socket with test light; repair
Lights on in PARK or NEUTRAL	Bad automatic transmission transaxle selector switch or back-up lights switch	Disconnect connector from switch; if back-up lights go out after disconnection, replace switch
	Misadjusted switch	Adjust switch

ASSIGNMENT SHEET 5

1. Fuse or switch
2. Yes
3. No
4. No
5. Yes

ASSIGNMENT SHEET 6

1. All
2. All
3. All
4. All
5. All
6. One

ASSIGNMENT SHEET 7

1. Total system failure
2. Trunk light, console courtesy light, dome light, reading light, radio, heater, convenience center, and rear dome light fail to function.
3. Blows courtesy lights and all cigarette lights, blows fuse, lose radio, heater, instrument panel, and trunk light.
4. Courtesy lights will not function with left door open; will when right door is open.
5. Reading, dome, console courtesy, left and right courtesy lights will not light when only the right front door open, but will operate in other cases.

JOB SHEET 1

LIGHTING SYSTEM

V

OBJECTIVE 11a

Inspect, test, and replace headlights.

TOOLS AND EQUIPMENT

- Service manual
- Test lamp
- Ohmmeter
- Safety glasses
- Fender covers

PROCEDURE

Test and replace components.

1. Refer to the service manual for proper procedures for the make and model being serviced.

2. Check headlamp for cracks, holes, discoloration, or moisture.

3. Test fuses and wiring according to service manual instructions.

4. Replace fuses, headlight switch, or dimmer switch, as indicated, following recommended procedures.

5. Remove the headlight and test it.

   a. Remove the headlight trim ring.

      NOTE: Do not turn headlight adjustment screws. Only headlight ring Bezel screws.

   b. Remove retaining ring screws and retaining ring.

   c. Remove lamp.

   d. Disconnect the wiring assembly plug from the lamp.

   e. Connect the lamp to a battery. If the lamp lights, it is good. If the lamp does not light, it should be replaced.

   f. Reinstall lamp by reversing steps a-e.

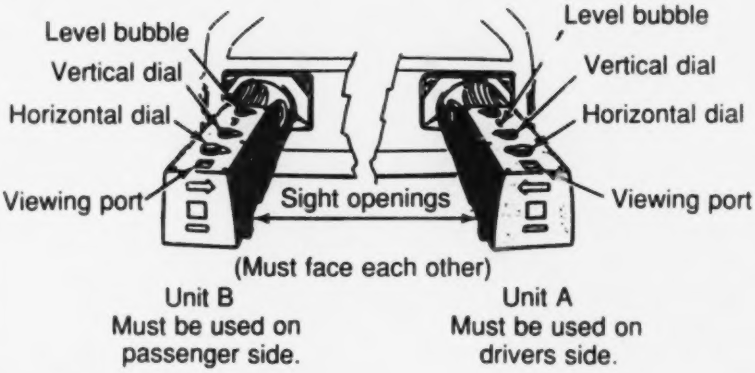
6. Test the headlight switch according to service manual instructions.

   NOTE: Wiring and connections vary between makes and models. Always refer to a wiring diagram and service manual to test lighting circuits.

PROCEDURE

Aim headlights.

1. Adjust car to reflect normal weight
   a. Check tires and adjust for proper inflation.
   b. If the manufacturer recommends it, someone may need to sit in the driver and passenger seat.
2. If aimers are used, follow the instructions accompanying the equipment.


Level bubble
Vertical dial
Horizontal dial
Viewing port
Sight openings
(Must face each other)
Unit B
Must be used on passenger side.
Level bubble
Vertical dial
Horizontal dial
Viewing port
Unit A
Must be used on drivers side.

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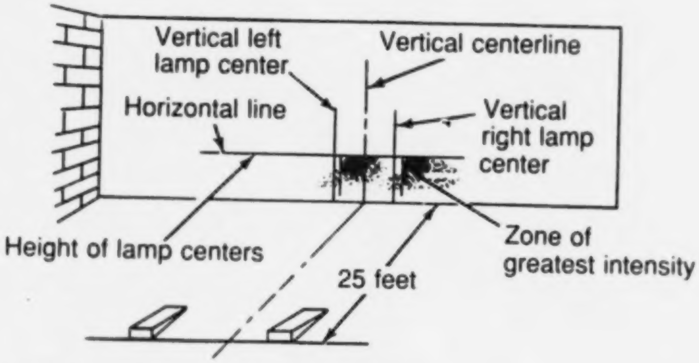
3. If an aiming screen is used:
   a. Park the car 25 feet from the screen.
   b. Turn on headlights.
   c. Brightest intensity should be where indicated in the following illustration.


Vertical left lamp center
Vertical centerline
Horizontal line
Vertical right lamp center
Height of lamp centers
Zone of greatest intensity
25 feet

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d. Adjust light beam, following manufacturer's service manual instructions or state vehicle inspection laws. State inspection regulations take precedent over manufacfacturer's specifications.

e. Repeat until both high and low beams have been adjusted.

4. Have your instructor check your work.

5. Put away tools and equipment and clean the work area.

JOB SHEET 2

LIGHTING SYSTEM

V

OBJECTIVE 11b

Inspect and service taillight/parking light subsystem.

TOOLS AND EQUIPMENT

- Service manual
- Jumper wires
- Ohmmeter
- Test lamp
- Service manual
- Safety glasses
- Fender covers
- Wiring diagram

PROCEDURE

1. Locate the proper service manual instructions.
2. Turn the ignition to ON.
3. Turn the light switch to the park position and check lights.
4. Turn the light switch to ON and check lights.
5. Consult the service manual wiring diagram for other lighting subsystems that use the taillight/parking light circuit.
6. Turn on the lights in all systems using the taillight/parking light circuit and see if they operate.
7. If the lights work when other subsystems are powered, but not when the taillights or parking lights are powered, check that part of the circuit used only by the taillight or parking light. Use the service manual wiring diagram and procedures to determine proper testing procedures.
8. If the lights fail to work when any system using the circuit is powered, check areas the circuits have in common.
    a. If only one light is affected on a single filament bulb, replace the bulb. If it still fails to operate, connect a test lamp to ground and test the center terminal of the light socket for continuity and wiring to the socket for continuity. Replace or repair socket and wiring as indicated.

   b. If all lights fail to operate, check wiring and switches for proper operation, according to manufacturer's service manual procedures.

9. Replace or repair circuit wiring and loads according to service manual procedures.

10. Have your instructor check your work.

11. Put away tools and equipment and clean the work area.

JOB SHEET 3

LIGHTING SYSTEM

OBJECTIVE 11c

Inspect and service turn and hazard signal subsystems.

TOOLS AND EQUIPMENT

- Service manual
- Jumper wires
- Ohmmeter
- Test light
- Safety glasses
- Fender covers

PROCEDURE

1. With the service manual, determine what other systems use the same circuitry.
2. Turn the ignition to ON. Activate the turn signals. Check that all lights in the circuit flash (in some circuits, this will include side marker lights).
3. Turn the hazard lights on and check that all lights flash.
4. Turn on other lights in the circuit and check their operation.
5. Use the troubleshooting chart and repair procedures in the service manual to diagnose and repair the system. As in other systems, if the turning signals/hazard lights are the only affected system, test circuitry used only by them. If other systems are affected, check common circuitry.
6. Have your instructor check your work.
7. Put away tools and materials and clean the work area.

JOB SHEET 4

LIGHTING SYSTEM

V

OBJECTIVE 11d

Inspect and service back-up light subsystem.

TOOLS AND EQUIPMENT

- Service manual
- Ohmmeter
- Jumper wires
- Test light
- Safety glasses
- Fender covers

PROCEDURE

1. Turn ignition ON and put the gear shift lever in park if the car is an automatic; neutral if it is a manual.

   CAUTION

   Make sure the emergency brake is on.

2. Check lights (should not be lit).
3. Put gear shift lever in reverse.
4. Check lights (should be lit).
5. Put gear shift lever in neutral.
6. Check lights (should not be lit).
7. Perform the following:
   - If only one light malfunctioned, replace the bulb and check the socket and wiring.
   - If the lights did not operate, check circuitry for faults according to service manual procedures.
   - If the lights operated, but went on and off in the wrong gears, adjust or replace the selector or the back-up light switch.
8. Have your instructor check your work.
9. Put away tools and equipment and clean the work area.

JOB SHEET 5

LIGHTING SYSTEM

OBJECTIVE 11e

Inspect and service brake/collision lights.

TOOLS AND EQUIPMENT

- Service manual
- Test light
- Ohmmeter
- Jumper wires
- Safety glasses
- Fender covers

PROCEDURE

1. Refer to the service manual to determine what other systems share circuitry with the brake/collision system.

2. Turn the ignition to ON and depress brake. Check lights (remember the high level brake light on late model cars).

3. Activate other systems, such as turning signal or back-up light systems, that share circuitry. Check to see if lights operate.

4. Perform the following:

   — If none of the systems operate correctly, refer to the service manual and check common circuitry according to service manual procedures.

   — If only one light fails to operate properly, replace the bulb, check the socket and wiring, according to service manual procedures.

   — If only the brake/collision system fails to operate properly, refer to the service manual and check circuitry used solely by that system.

5. Repair or replace faulty wiring or loads according to service manual procedures.

6. Have your instructor check your work.

7. Put away tools and equipment and clean the work area.

JOB SHEET 6

LIGHTING SYSTEM

V

OBJECTIVE 11f

Inspect and service dashlight subsystems.

TOOLS AND EQUIPMENT

- Service manual
- Ohmmeter
- Jumper wires
- Test lamp
- Fender covers
- Safety glasses

PROCEDURE

1. Locate the correct page in the service manual.
2. Turn the ignition to ON and turn headlights on. Check that all dash lights are on.
3. Turn headlight switch to dim and brighten dash lights.
4. Perform the following:
   - If no interior lights work, check tail fuse, instrument panel fuse, printed circuit board, light switch, and system wiring, according to service manual instructions.
   - If a group of lights does not work, check wiring diagram for common circuitry then test that circuitry for continuity, according to service manual instructions.
   - If a single light does not work, replace the bulb, test the socket, and wiring.
   - If the dimmer switch does function properly, replace the light switch according to service manual instructions.
   - If the lights will not turn off, replace the light switch, according to service manual instructions.
5. Have your instructor check your work.
6. Put away tools and equipment and clean the work area.

JOB SHEET 7

LIGHTING SYSTEM

OBJECTIVE 11g

Inspect and service courtesy light subsystem.

TOOLS AND EQUIPMENT

- Service manual
- Test light
- Ohmmeter
- Jumper wires
- Fender covers
- Safety glasses

PROCEDURE

1. Consult the service manual to locate each courtesy light and each switch.
2. Check each courtesy light for proper operation by activating each switch (open doors one at a time, check individual switches, etc.).
3. If only one component or light does not function, replace the bulb, check the socket and wiring for continuity.
4. If none of the components or lights operate, check fuses and wiring for continuity, according to service manual procedures. Check that grounds are clean and tight.
5. If a group of components or lights fail to operate, use the service manual to locate common circuitry and follow service manual testing procedures.
6. Have your instructor check your work.
7. Put away tools and equipment and clean the work area.

PRACTICAL TEST 1

LIGHTING SYSTEM

V

JOB SHEET 1

Inspect, test, and replace headlights.

STUDENT'S NAME ________________ DATE ____________

EVALUATOR'S NAME ________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Removed the headlight trim ring.	_____	_____
2. Removed retaining ring screws and retaining ring.	_____	_____
3. Removed lamp and disconnected the wiring assembly plug from the lamp.	_____	_____
4. Connected the lamp to a battery.	_____	_____
5. Tested the headlight switch according to service manual instructions.	_____	_____
6. Tested fuses according to service manual instructions.	_____	_____
7. Tested wiring according to service manual instructions.	_____	_____
8. Replaced fuses as indicated, following recommended procedures.	_____	_____

	YES	NO
9. Replaced headlight switch as indicated, following recommended procedures.	____	____
10. Replaced dimmer switch, as indicated, following recommended procedures.	____	____
11. Adjusted headlights.	____	____
12. Reinstalled headlights.	____	____
13. Used proper tools correctly.	____	____
14. Performed steps in a timely manner.	____	____
15. Practiced safety rules throughout procedure.	____	____
16. Provided satisfactory responses to questions asked.	____	____
17. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Removed and tested headlamp	4	3	2	1
Tested light switch	4	3	2	1
Tested fuses and wiring according to directions	4	3	2	1
Diagnosed need for replacements correctly and replaced defective parts	4	3	2	1
Aimed headlights properly	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

LIGHTING SYSTEM

JOB SHEET 2

Inspect and service taillight/parking light subsystem.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Turned the ignition to ON and turned the light switch to the park (fog light) position and on position; checked lights.	____	____
2. Consulted the service manual wiring diagram for other lighting subsystems that use the taillight/parking light circuit.	____	____
3. Turned on the lights in all systems using the taillight/parking light circuit and see if they operate.	____	____
4. If the lights worked when other subsystems were powered, but not when the taillights or parking lights were powered, checked that part of the circuit used only by the taillight or parking light, using the service manual wiring diagram and procedures.	____	____

or

	YES	NO
4. If the lights failed to work when any system using the circuit was powered, checked areas the circuits have in common, using the service manual wiring diagram and procedures.	____	____
5. Replaced or repaired circuit wiring and loads according to service manual procedures.	____	____
6. Used proper tools correctly.	____	____
7. Performed steps in a timely manner.	____	____
8. Practiced safety rules throughout procedure.	____	____
9. Provided satisfactory responses to questions asked.	____	____
10. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Determined all connected systems and operated lights for visual check	4	3	2	1
Determined proper portion of circuit to test and tested properly	4	3	2	1
Diagnosed fault properly	4	3	2	1
Replaced loads and retested properly	4	3	2	1
Repaired wiring properly and retested	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3

LIGHTING SYSTEM

V

JOB SHEET 3

Inspect and service turn and hazard signal subsystems.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Used the service manual to determine what other systems use the same circuitry.	_____	_____
2. Turned the ignition to ON and turned on the turn signals. Checked that all lights in the circuit flashed.	_____	_____
3. Turned the hazard lights on and checked that all lights flashed.	_____	_____
4. Turned on other lights in the circuit and checked their operation.	_____	_____
5. Used the troubleshooting chart and repair procedures in the service manual to diagnose and repair the system.	_____	_____
6. Used proper tools correctly.	_____	_____
7. Performed steps in a timely manner.	_____	_____
8. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
9. Provided satisfactory responses to questions asked.	_____	_____
10. Put away tools and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Used service manual to locate common circuitry	4	3	2	1
Turned on and visually checked turn signals, hazard lights, and all connected systems	4	3	2	1
Located and used correct trouble-shooting chart correctly	4	3	2	1
Located and serviced fault according to service manual instructions	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program, additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 4

LIGHTING SYSTEM

V

JOB SHEET 4

Inspect and service back-up light subsystem.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Turned the ignition to ON and the gear shift lever in park if the car was an automatic; neutral if it was a manual; checked lights.	____	____
2. Put gear shift lever in reverse and checked lights.	____	____
3. Put gear shift lever in neutral and checked lights.	____	____
4. Performed the following as indicated:		
— if only one light malfunctioned, replaced the bulb and checked the socket and wiring.	____	____
— if the lights did not operate, checked circuitry for faults according to service manual procedures.	____	____

	YES	NO
— if the lights operated, but went on and off in the wrong gears, adjusted or replaced the selector switch or the back-up light switch according to service manual instructions.	____	____
5. Used proper tools correctly.	____	____
6. Performed steps in a timely manner.	____	____
7. Practiced safety rules throughout procedure.	____	____
8. Provided satisfactory responses to questions asked.	____	____
9. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ______________________________

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Checked lights in park or neutral, in reverse, then in neutral.	4	3	2	1
Located and followed proper service manual instructions	4	3	2	1
Performed all tests indicated according to instructions	4	3	2	1
Repaired or replaced fault according to directions	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 5

LIGHTING SYSTEM

JOB SHEET 5

Inspect and service brake/collision lights.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Referred to the service manual to determine what other systems share circuitry with the brake/collision system.	____	____
2. Turned the ignition to ON and depressed brake. Checked lights.	____	____
3. Activated other systems and checked to see if lights operated properly.	____	____
4. Performed the following:		
— if none of the systems operated correctly, referred to the service manual and checked common circuitry according to service manual procedures.	____	____
— if only one light failed to operate properly, replaced the bulb, checked the socket and wiring, according to service manual procedures.	____	____

	YES	NO
— if only the brake/collision system failed to operate properly, referred to the service manual and checked circuitry used solely by that system.		
5. Repaired or replaced faulty wiring or loads according to service manual procedures.		
6. Used proper tools correctly.		
7. Performed steps in a timely manner.		
8. Practiced safety rules throughout procedure.		
9. Provided satisfactory responses to questions asked.		
10. Put away tools and cleaned work area.		

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Located all lighting systems that share circuitry	4	3	2	1
Tested all indicated areas as instructed	4	3	2	1
Located and serviced fault with difficulty	4	3	2	1
Used service manual and wiring diagram correctly	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 6

LIGHTING SYSTEM

V

JOB SHEET 6

Inspect and service dashlight subsystems.

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. _

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Turned the ignition to ON and turned headlights on. Checked that all dash lights were on.	_____	_____
2. Turned headlight switch to dim and brighten dash lights.	_____	_____
3. Performed the indicated tests:		
— if no interior lights worked, checked tail fuse, instrument panel fuse, printed circuit board, light switch, and system wiring, according to service manual instructions.	_____	_____
— if a group of lights did not work, checked wiring diagram for common circuitry then tested that circuitry for continuity, according to service manual instructions.	_____	_____
— if a single light did not work, replaced the bulb, tested the socket, and wiring.	_____	_____

	YES	NO
— if the dimmer switch did not function properly, replaced the light switch according to service manual instructions.	____	____
— if the lights would not turn off, replaced the light switch, according to service manual instructions.	____	____
4. Used proper tools correctly.	____	____
5. Performed steps in a timely manner.	____	____
6. Practiced safety rules throughout procedure.	____	____
7. Provided satisfactory responses to questions asked.	____	____
8. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Turned on lights, observed performance, and made correct evaluation	4	3	2	1
Tested circuit according to service manual procedures	4	3	2	1
Repaired or replaced faulted portion of circuit	4	3	2	1
Understood and used wiring diagram at all times	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 7

LIGHTING SYSTEM

V

JOB SHEET 7

Inspect and service courtesy light subsystem.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Consulted the service manual to locate each courtesy light and each switch.	_____	_____
2. Checked each courtesy light for proper operation.	_____	_____
3. Activated each switch.	_____	_____
4. If only one component or light did not function, replaced the bulb, checked the socket and wiring for continuity.	_____	_____
5. If none of the components or lights operated, checked fuses and wiring for continuity, according to service manual procedures.	_____	_____
6. Checked that grounds were clean and tight.	_____	_____
7. If a group of components or lights failed to operate, used the service manual to locate common circuitry and followed service manual testing procedures.	_____	_____

	YES	NO
8. Used proper tools correctly.	____	____
9. Performed steps in a timely manner.	____	____
10. Practiced safety rules throughout procedure.	____	____
11. Provided satisfactory responses to questions asked.	____	____
12. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Located all courtesy lights and switches by referring to service manual	4	3	2	1
Checked the operation of each light as activated by each switch	4	3	2	1
Located and followed proper service manual procedures	4	3	2	1
Located and serviced fault with difficulty	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

LIGHTING SYSTEM

V

NAME ______________________________ SCORE ________

OBJECTIVE 1

Complete statements about headlight systems.

1. The headlight system includes the headlamps, ___________ and ____________ switches, a fuse panel, the battery and wiring.
2. The taillights, ___________________ lights, and marker lights are also connected in circuit.
3. The headlight switch contains an on/off switch and a ______________________________ that controls the current flow to the bulbs in the instrument panel.
4. Three types of bulbs can be used, those with _______ ______________, those with ______________________, and halogen headlamps.

OBJECTIVE 2

Match names and descriptions of exterior lighting systems. Write the correct letters in the blanks. Some answers will be used more than once.

______1. When the switch is activated, current is sent to all four turning signals

______2. Two types of switches are the basic switch and the multi-purpose switch that also includes a horn and dimmer switch

______3. When the headlights are turned on, these also come on

______4. The switch is located on the transmission

______5. Contains the turning signal system circuit and a switch

a. Turn signal lights

b. Hazard lights

c. Taillight/parking lights

d. Back-up lights

e. Brake/collision lights

_____ 6. Usually a push/pull switch on the steering column

_____ 7. The switch is sometimes located on the gear shift lever

_____ 8. Depressing the brake pedal closes the switch, completing the circuit

_____ 9. The flasher unit containing a circuit breaker is usually found on the fuse panel

OBJECTIVE 3 **Describe interior lighting systems.**

Dash light system

____

____

____

____

Courtesy light system

____

____

____

____

NOTICE The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.

OBJECTIVE 4 **Diagnose headlight problems.** SCORE _____

OBJECTIVE 5 **Diagnose taillight/parking light problems.** SCORE _____

OBJECTIVE 6 **Diagnose turn and hazard signal problems.** SCORE _____

OBJECTIVE 7	Diagnose back-up light problems.	SCORE ______
OBJECTIVE 8	Diagnose brake/collision light problems.	SCORE ______
OBJECTIVE 9	Diagnose dash light problems.	SCORE ______
OBJECTIVE 10	Diagnose courtesy light problems.	SCORE ______
OBJECTIVE 11a	Inspect, test, and replace headlights.	RATING ______
OBJECTIVE 11b	Inspect and service taillight/parking light subsystem.	RATING ______
OBJECTIVE 11c	Inspect and service turn and hazard signal subsystem.	RATING ______
OBJECTIVE 11d	Inspect and service back-up light subsystem.	RATING ______
OBJECTIVE 11e	Inspect and service brake/collision lights.	RATING ______
OBJECTIVE 11f	Inspect and service dashlight subsystems.	RATING ______
OBJECTIVE 11g	Inspect and service courtesy light subsystem.	RATING ______

WRITTEN TEST ANSWERS

LIGHTING SYSTEM

V

OBJECTIVE 1

1. light and dimmer
2. instrument
3. variable resistor OR rheostat
4. one element
   two elements

OBJECTIVE 2

1. b
2. a
3. c
4. d
5. b
6. b
7. d
8. e
9. a or b

OBJECTIVE 3

Answers should include the following:

- Dash lights
  - — The headlight switch includes a switch controlling current flow to the dash board lights. When the switch is on, current flows through switch and a rheostat. The rheostat increases or decreases resistance in the circuit, increasing or decreasing the brightness of the dashboard lighting.
- Courtesy lights
  - — Courtesy lights include the dome light, trunk light, engine compartment light, glove box light, cigarette lighter and light, reading lights and other comfort system lights.
  - — Courtesy lights are connected in parallel to circuits that always receive current.
  - — Most courtesy lights are controlled by their own switch connected to ground. When the switch is closed (as may happen when a door is opened), the circuit becomes grounded and therefore complete.

- Some courtesy lights may be controlled by more than one switch. For example, the dome light is controlled by a dome light switch and by the individual door jamb switches.

OBJECTIVE 4 Refer to Answers to Assignment Sheet 1.

OBJECTIVE 5 Refer to Answers to Assignment Sheet 2.

OBJECTIVE 6 Refer to Answers to Assignment Sheet 3.

OBJECTIVE 7 Refer to Answers to Assignment Sheet 4.

OBJECTIVE 8 Refer to Answers to Assignment Sheet 5.

OBJECTIVE 9 Refer to Answers to Assignment Sheet 6.

OBJECTIVE 10 Refer to Answers to Assignment Sheet 7.

OBJECTIVE 11a Refer to Practical Test 1.

OBJECTIVE 11b Refer to Practical Test 2.

OBJECTIVE 11c Refer to Practical Test 3.

OBJECTIVE 11d Refer to Practical Test 4.

OBJECTIVE 11e Refer to Practical Test 5.

OBJECTIVE 11f Refer to Practical Test 6.

OBJECTIVE 11g Refer to Practical Test 7.

OBJECTIVE SHEET

HORN AND WASHER/WIPER SYSTEMS

VI

INTRODUCTION

The horn and washer/wiper systems are important safety and comfort systems. Many states require that they function properly for an automobile to pass safety inspections. In some climates or seasons, they are vitally important.

UNIT OBJECTIVE

After completing this unit, the student should be familiar with the components, operation, and servicing of horn and washer/wiper systems. The student will demonstrate these competencies by completing assignments sheets, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to:

1. List horn components and horn assembly parts.
2. Complete statements about the operation of a horn.
3. List components of the wiper system.
4. Identify true statements about the operation of a wiper system.
5. Describe the two types of wiper switches.
6. Label components of the washer system.
7. Describe the operation of the washer system.
8. Diagnose horn problems. (Assignment Sheet 1)
9. Diagnose wiper system problems. (Assignment Sheet 2)
10. Diagnose washer system problems. (Assignment Sheet 3)
11. Demonstrate an ability to:
    a. Inspect and service horns. (Job Sheet 1)
    b. Inspect and repair wiper systems. (Job Sheet 2)
    c. Inspect and service washer systems. (Job Sheet 3)

SUGGESTED ACTIVITIES

HORN AND WASHER/WIPER SYSTEMS

VI

PREPARATION

- Review unit and plan presentation.

- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.

- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.

- Review teaching suggestions and plan classroom activities.

- Determine how you will schedule time for students to demonstrate competence in the required procedures.

- Order materials to supplement unit.

DELIVERY

Objective 1 List horn components and horn assembly parts.
Objective 2 Complete statements about the operation of a horn.

- Allow students to test a variety of horns and trace several horn circuits. Have students compare them, noting the age of the car, the size and sound of the diaphragm, and the other connected systems.

- Have students complete Assignment Sheet 1 and Job Sheet 1.

Objective 3 List components of the wiper system.
Objective 4 Identify true statements about the operation of a wiper system.
Objective 5 Describe the two types of wiper switches.

- Allow students to test and service standard and pause systems and compare the two.

- Have students consider other systems connected in the circuit.

- Have students complete Assignment Sheet 2 and Job Sheet 2.

Objective 6 **Label components of the washer system.**
Objective 7 **Describe the operation of the washer system.**

- Show students how to check hose for kinks, blocks, and breaks. Have students trace the hose as well as circuit wiring.

- Discuss the difference between electrical and mechanical.

- Have students compare the pump motor with other motors.

- Have students complete Assignment Sheet 3 and Job Sheet 3.

APPLICATION

Objective 8 **Diagnose horn problems.** (Assignment Sheet 1)
Objective 9 **Diagnose wiper system problems.** (Assignment Sheet 2)
Objective 10 **Diagnose washer system problems.** (Assignment Sheet 3)

- Have students reason and solve the procedures and tests, based on previous lessons.

- If necessary, have students complete the tests described.

- Make sure students have completed Assignment Sheets 1-3.

Objective 11 **Demonstrate an ability to:**
  a. **Inspect and service horns.** (Job Sheet 1)
  b. **Inspect and repair wiper systems.** (Job Sheet 2)
  c. **Inspect and service washer systems.** (Job Sheet 3)

- Make sure students have completed Job Sheets 1-3.

- Stress the necessity to use service manuals, not this curriculum as a source of procedure instructions.

EVALUATION

Pretest

- Pretest qualifying students.

- Determine individual requirements from pretest results.

- Counsel students individually on pretest results and study requirements.
- Modify materials in unit or create supplementary materials for individual students as required.

Practical tests

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical tests.
- Describe the rating scale used on the practical tests.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.
- Complete appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Publications

- General Motors offers *Windshield Wiper Systems*, (#GM-19007-23). It includes general, motor, pulse, and pump operation, diagnostic procedures, and instructions for disassembly. Order from General Motors Training, Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28635 Mound Rd., Warren, MI 48092, 1-800-468-6657.

UNIT REFERENCES

- *Diagnosis and Troubleshooting of Automotive Electrical, Electronic, and Computer Systems*, James D. Halderman, 1991. A book designed to improve diagnostic and troubleshooting skills in independent or classroom study. Well illustrated and comprehensive, with current information on computer principles, sensors, diagnosis, and troubleshooting; also covers all electrical systems. Available from Prentice Hall, College Operations, Englewood Cliffs, NJ 07632.
- *1989 Prelude Service Manual.* Honda Motor Co., Ltd., 1988.
- Crouse, William H. and Donald L. Anglin. *The Auto Book.* New York: McGraw-Hill Book Company, 1984.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- *Auto Electricity, Electronics, Computers.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1990.
- Toboldt, William K. and Larry Johnson. *Automotive Encyclopedia.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1983.
- *Windshield Wiper Systems.* General Motors, Corp., 1986.

HORN AND WASHER/WIPER SYSTEMS

EVALUATOR

Use the following answer key to check student answers to pretest questions. **NOTE:** To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions.

Objective	Question
1	1-2
2	3-6
3	7
4	8-9
5	10-11
6	12
7	13-14
8	15-16
9	18-20
10	21-22
11	18-22

ANSWER KEY

1. a
2. b
3. b
4. a
5. b
6. c
7. a
8. c
9. a
10. b
11. b
12. b
13. a
14. c
15. b
16. b
17. c
18. c
19. d
20. b
21. a
22. a

HORN AND WASHER/WIPER SYSTEMS

NAME ________________________________ SCORE _______

Complete each statement by writing the correct answer in the blank next to the statement.

______1. All of the following are components in the horn system EXCEPT ___.

a. volume and pitch control
b. horn assembly
c. switch and horn relay
d. wiring

______2. The horn assembly contains ___.

a. a switch and a relay
b. an armature, a diaphragm, contacts and resistors
c. a bulb, amplifier, and a switch

______3. The horn diaphragm moves because ___.

a. gears connected to it pull it
b. an electromagnet pulls the armature
c. air forced through the bulb rushes against it

______4. As the diaphragm moves, contact points are ___.

a. pulled apart
b. brought into contact
c. flooded with current

______5. The diaphragm moves back into place when ___.

a. air is no longer rushing from the bulb
b. the electromagnet loses current
c. springs pull it into position

______6. What we hear as one continuous sound is really ___.

a. a variety of sounds and pitches produced by several diaphragms
b. a continuous electronic "beep"
c. the bursts of sound of the diaphragm being pulled out of position and back again

______7. The wiper system contains ___.

a. a switch, wiper arms, a wiper control circuit, a wiper motor assembly, and wiper linkage
b. a switch, wiper blades, a wiper control circuit, a wiper linkage, and connections to the battery and alternator
c. a system of gears that link to alternator gears, a switch, wiper arms, a wiper motor, and linkage

______8. When the wiper switch is activated, the circuit is grounded, and current is supplied to the circuit from the ___.

a. alternator
b. wiper motor
c. battery

______9. The speed at which the wipers operate is determined by how much voltage is in the ___.

a. contacts located in the switch
b. brushes located in the motor
c. battery

_____10. The rotation of the motor shaft is transformed to a back-and-forth motion by the ___.

a. linkage
b. wiper control circuit
c. wiper motor transmission

_____11. The time between sweeps in a system with a pulse feature is determined by ___.

a. voltage limits of circuit breakers
b. variable resistors in the circuit
c. voltage fed through the brushes

_____12. How many basic types of switches are there?

a. Four
b. Two
c. One

_____13. When the washer switch is activated, current is sent to the ___.

a. washer pump
b. washer nozzle
c. washer hose

_____14. Fluid is drawn from the reservoir and forced through the hose by the ___.

a. washer pump
b. piston spring expanding and contracting
c. both a and b

_____15. Horn problems occur most often in ___.

a. the horn only
b. the switch or circuit only
c. either the horn or switch /circuit

_____16. The first step in testing a horn is to ___.

a. connect jumper cables from the horn to the battery and from the horn to ground
b. connect a test lamp to circuitry leading to the horn
c. test the switch for continuity according to service manual procedures

_____17. If a horn is faulty, it should be ___.

a. bench tested and repaired
b. electronically diagnosed and repaired
c. replaced

_____18. All wiper systems include circuit protection devices to protect against overload ___.

a. in times of increased use
b. in case of shorts or grounds
c. when windshields are iced over

_____19. If a wiper motor is receiving voltage, a likely reason for poor performance is ___.

a. poor grounding
b. worn gears
c. neither a nor b
d. both a and b

_____20. If a wiper motor is not receiving current, ___.

a. check the battery
b. test the switch and circuitry
c. test the armature

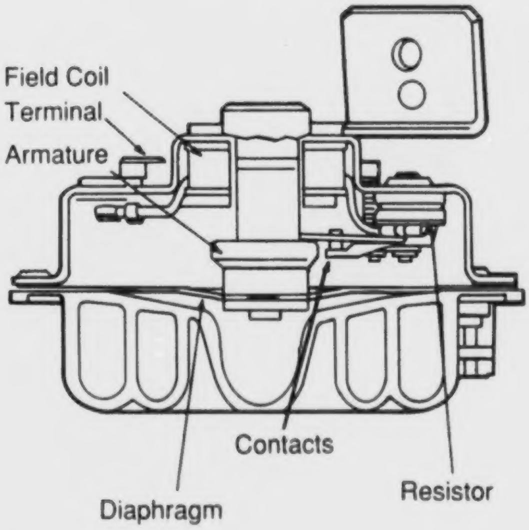
_____21. The first thing to check in a malfunctioning washer system is ___.

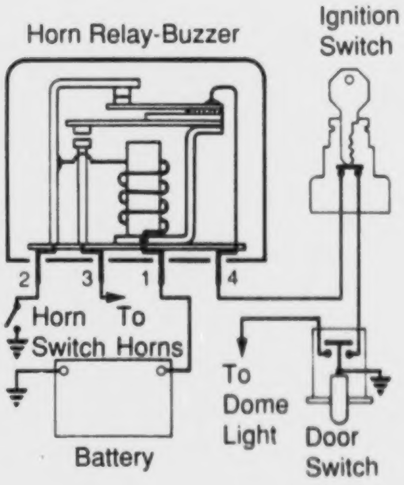
a. the reservoir and hoses
b. the pump
c. the switch

_____22. If the pump motor does not operate but is receiving proper voltage, it should be ___.

a. replaced
b. bench tested and serviced
c. electronically diagnosed and serviced

OBJECTIVE 1 **List horn components and horn assembly parts.**


Field Coil
Terminal
Armature
Contacts
Diaphragm
Resistor


Horn Relay-Buzzer
Ignition Switch
2
3
1
4
Horn Switch
To Horns
Battery
To Dome Light
Door Switch

Used with permission of Glencoe/McGraw-Hill Book Company.

- Horn assembly parts
  - Coil
  - Armature
  - Diaphragm
  - Contacts
  - Resistor

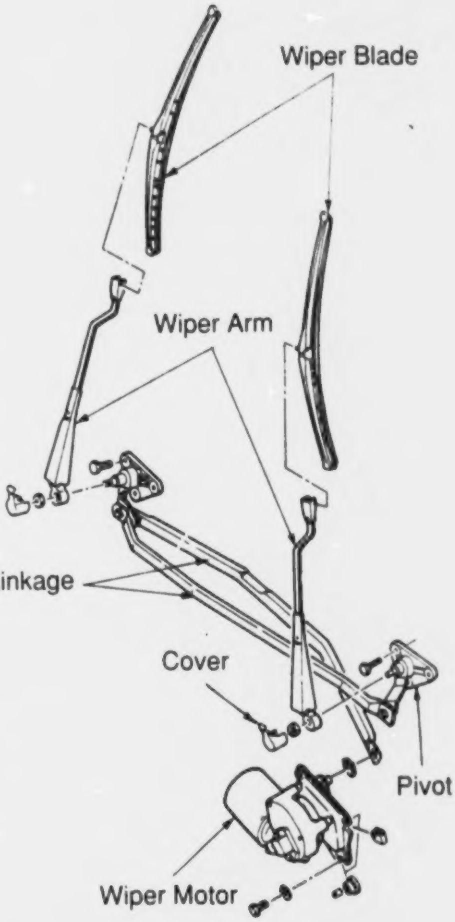
- Horn system components
    - Switch
    - Horn relay
    - Wiring

OBJECTIVE 2 **Complete statements about the operation of a horn.**

- Current flows to an electromagnet that pulls on an armature connected to the diaphragm.
- As the diaphragm moves, contact points are pulled apart and the circuit is opened.
- The electromagnet loses current (and thus magnetism) and the armature and diaphragm move back to their original place.
- The contact points come back into contact and the circuit is closed.
- Current flows back into the electromagnet and the cycle begins again.
- The cycle is repeated so quickly, the bursts of sound as the armature and diaphragm are pulled out of place are heard as one continuous sound.

OBJECTIVE 3

List components of the wiper system.


Wiper Blade
Wiper Arm
Linkage
Cover
Pivot
Wiper Motor

Used with permission of Nissan Motor Co., LTD.

- Switch (on dash or turn signal switch)
- Wiper arms
- Wiper control circuit (wiring harness)
- Wiper motor assembly
- Wiper linkage

OBJECTIVE 4

Identify true statements about the operation of a wiper system.

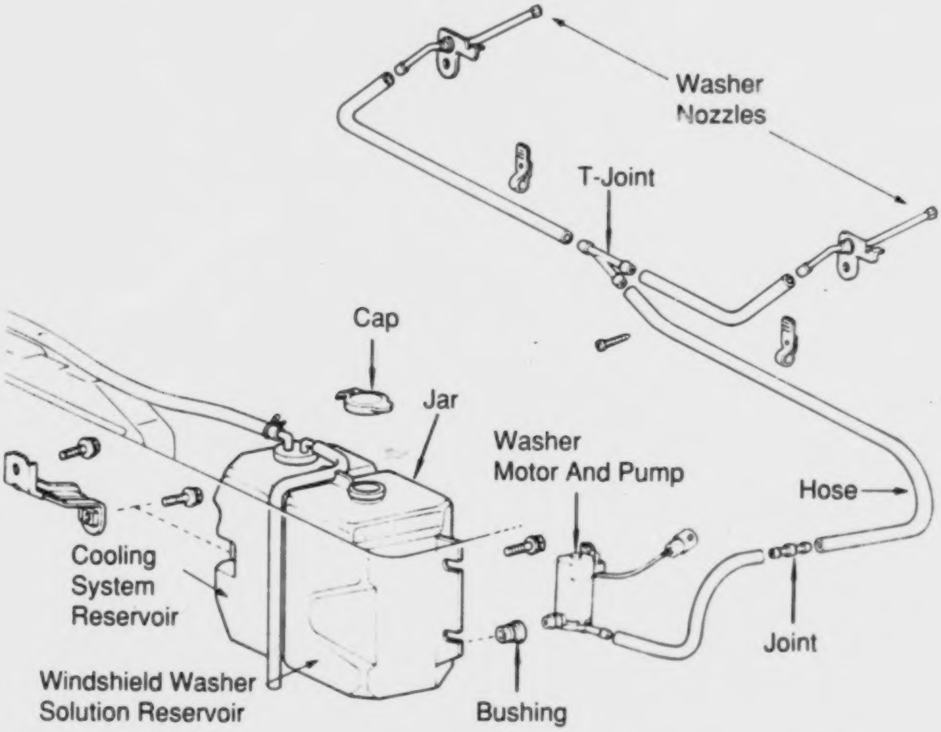
- Voltage is supplied from the battery to the wiper motor when the wiper switch is activated, grounding the circuit.
- Contacts located in the switch control current through or around resistors that adjust wiper speed.
- The wiper motor shaft turns.
- The wiper motor transmission uses a series of gears to transform the motor shaft's rotations to a back-and-forth motion.
- The wiper linkage transfers the back-and-forth motion to the wiper blades.
- If a pulse feature is included in the system, a control unit monitors voltage. When wipers complete a wiping cycle and return to the PARK position, the circuit is opened. A relay begins to re-energize. Variable resistors in the circuit determine the amount of time it takes to energize the relay. When it is recharged, the circuit is closed and the wipers begin another cycle.

OBJECTIVE 5

Describe the two types of wiper switches.

- Most late-model cars have a multi-function lever on the steering column. It is used as a turning signal by moving the lever up or down, as a wiper switch by turning the knob, and as a washer switch by depressing a button on the end of the lever.
- Some cars have a separate switch, either on the steering column or on the dash board, that controls only the washer/wiper system.

OBJECTIVE 6 **Label components of the washer system.**

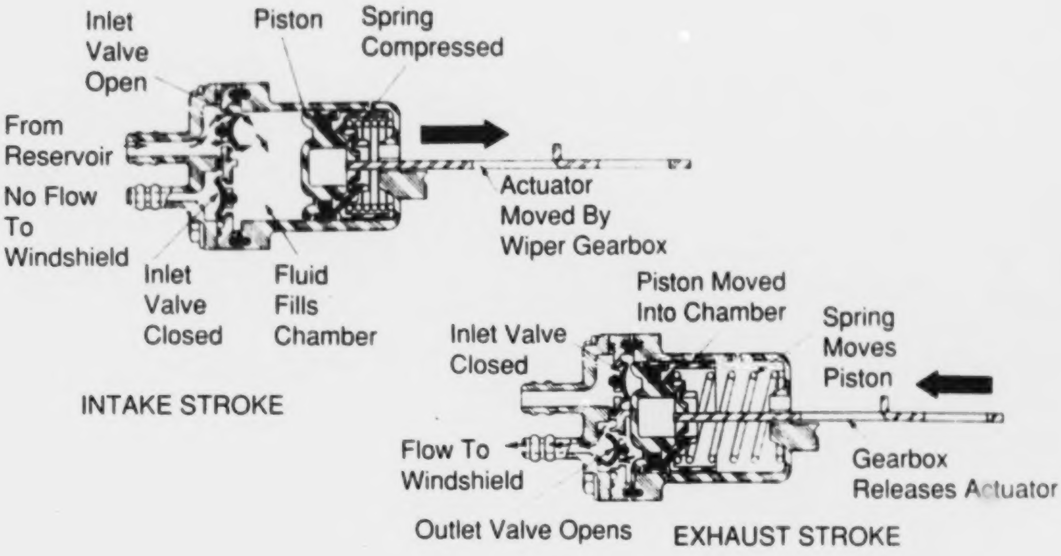

Washer Nozzles
T-Joint
Cap
Jar
Washer Motor And Pump
Hose
Cooling System Reservoir
Joint
Windshield Washer Solution Reservoir
Bushing

Used with permission of Nissan Motor Co., LTD.

- Cooling System Reservoir
- Washer Motor/Pump
- Hose
- Washer Nozzles
- Bushing
- Washer Solution Reservoir
- Jar
- Joints

OBJECTIVE 7 Describe the operation of the washer system.

MECHANICAL

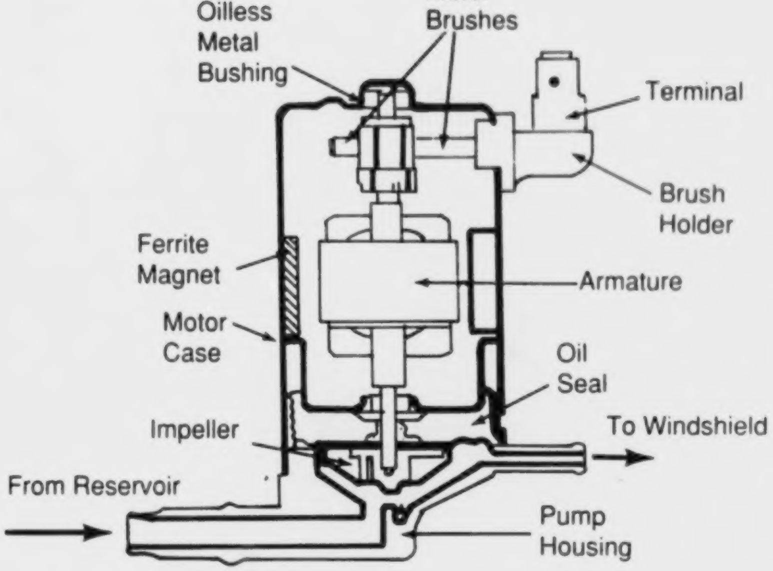

Inlet Valve Open
Piston
Spring Compressed
From Reservoir
No Flow To Windshield
Actuator Moved By Wiper Gearbox
Inlet Valve Closed
Fluid Fills Chamber
INTAKE STROKE
Piston Moved Into Chamber
Inlet Valve Closed
Spring Moves Piston
Flow To Windshield
Gearbox Releases Actuator
Outlet Valve Opens
EXHAUST STROKE

Used with permission of General Motors Corporation.

- When the washer switch is activated, the washer pump receives current.
- The magnet armature is pulled toward the coil.
- As the armature moves, the piston actuator plate is moved from in front of the piston spring.
- The piston spring is allowed to expand and contract, alternately drawing fluid from the reservoir and then forcing it to nozzles.

  NOTE: In some automobiles, this continues as long as the switch is depressed. In others, a ratchet gear rotates once then slides out of engagement and pumping is stopped.

ELECTRIC


Oilless
Metal
Bushing
Motor
Brushes
Terminal
Brush
Holder
Ferrite
Magnet
Armature
Motor
Case
Oil
Seal
Impeller
To Windshield
From Reservoir
Pump
Housing

- When the washer switch is activated, the pump receives current.

- The armature spins and spins the impeller, a fan-like blade.

- The fluid is pressurized and forced through the washer hoses and nozzles.

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PROPOSE IMPROVEMENTS TO HORN AND WASHER/WIPER SYSTEMS

DEVISE A BETTER HORN

The comedian Gallagher once suggested that horns are inefficient and should be replaced with dart guns and "Stupid Driver" darts. Rather than honking a horn, drivers could shoot the offending vehicle. Cars with too many darts would be pulled over by police and the driver cited for stupidity. While his suggestion may be impractical, there may be improvements in or replacements for a horn system. Present your idea to the class orally or on a poster.

DEVISE A BETTER WASHER/WIPER SYSTEM

Washer/wiper systems have grown from simple wipers on the windshield to front and back window systems with two blades on each wiper. What will the next improvement be? Sensors on the roof of the car activating the system when splashed with water? Sensors monitoring the amount of dirt on the windshield and cleaning the window automatically? Present your idea to the class orally or on a poster. Include a basic idea of how the circuit would work.

ASSIGNMENT SHEET 1

HORN AND WASHER/WIPER SYSTEMS

VI

NAME ______________________________ SCORE ________

OBJECTIVE 8 **Diagnose horn problems.**

INTRODUCTION There are three areas where horn problems may exist: in the switch, in the relay, or in the circuitry. It is rarely in the horn itself. If a horn fails to operate, check voltage at the relay. If it is okay, test with jumper wires. If it fails to operate when grounded and receiving current directly from the battery, it should be replaced. If it operates when grounded and receiving battery current, the switch or wiring is at fault. Fuses, fusible links, or circuit breakers should be checked and the switch tested. The switch is tested by checking the connector terminal for continuity. If continuity is good, the fault is in the wiring. If it is not good, the fault is in the switch. Horns are not repaired, they are replaced.

DIRECTIONS Complete the following statements, based on the information above and your understanding of electrical circuitry.

1. If a horn does not work and inspection yields a blown fusible link, should further testing be done after the link is replaced?
   ____
2. If a horn is removed from the car for inspection and linked to a good battery by a jumper wire but still fails to operate, can you determine if the horn is good or needs to be replaced?
   __________ Why or why not? ____________________
3. If a horn operates properly when grounded and jumped to the battery, and the switch connector terminal shows good continuity, what should be tested next?
   ____
4. List three instruments you could use to perform the test you describe in Question 3.
   ____
   ____
   ____

ASSIGNMENT SHEET 2

HORN AND WASHER/WIPER SYSTEMS

VI

NAME ________________________________ SCORE ________

OBJECTIVE 9 **Diagnose wiper system problems.**

INTRODUCTION

Wiper problems tend to be in three areas: the motor, the switch, and the connecting circuitry. The first thing to check is fuses, fusible links, and circuit breakers. All wiper systems contain circuit protection devices to prevent overload when windshields are iced over. After checking protection devices and connections, test for continuity to the wiper motor. If the motor is receiving power, make sure the motor is securely grounded. If the problem seems to be internal, check gears for wear. Replacing plastic gears will often solve the problem. If the motor is not receiving current, test the switch and wiring according to the service manual.

DIRECTIONS **Write the letter of the correct answer in the blank before the statement.**

______1. If a test lamp connected to wiring leading to the wiper motor lights but flickers off and on when the motor is jiggled, the most likely problem is ___.

a. a short in the wiring being tested
b. poor grounding connections at the wiper motor
c. a loose connection from the wiper motor to the wire being tested

______2. If a customer complains that during the recent snow storm his wipers quit working, it is very likely that ___.

a. mechanical failure is due to overload
b. the motor was shorted when overload occurred
c. the switch needs to be tested

______3. Preliminary testing indicates that the problem is within the wiper motor. Does the motor need to be replaced or serviced?

a. Replaced
b. Serviced
c. Cannot tell at this point.

______4. Testing for continuity to the wiper motor can be done with ___.

a. an ammeter
b. an ohmmeter
c. a jumper wire

ASSIGNMENT SHEET 3

HORN AND WASHER/WIPER SYSTEMS

VI

NAME ______________________ SCORE ________

OBJECTIVE 10 **Diagnose washer system problems.**

INTRODUCTION When problems in a washer system are presented, the first things to check are:

- Is the washer reservoir full?
- Are hoses pinched or kinked?
- Are hoses correctly attached?
- Are nozzles clogged?

If all these are checked and no problem is found, activate the washer and observe its performance. Check the service manual to compare described and actual performances. If the washer will not operate, test the motor voltage according to service manual procedures. If the motor is receiving proper voltage but does not work, it should be replaced. If it is receiving improper voltage, test circuits leading to the motor for resistance and test the switch.

DIRECTIONS Use the information above to prepare a basic troubleshooting chart for washer system problems.

Symptom	Cause	Action

HORN AND WASHER/WIPER SYSTEMS

ASSIGNMENT SHEET 1

1. Yes
2. No
   It is not grounded.
3. Relay
4. Voltmeter
   Multimeter
   Test lamp

ASSIGNMENT SHEET 2

1. c
2. a
3. a
4. b

ASSIGNMENT SHEET 3

Symptom	Cause	Action
Won't wash	No cleaner	Check and fill reservoir.
	Hoses pinched or clogged	Move or clean hoses. Replace hoses.
	Nozzles clogged	Clean or replace nozzles.
	Faulty motor	Test circuits leading to motor with a test lamp. If lamp lights, replace motor.
	Faulty switch	Test according to service manual. Repair or replace.
	Circuit open	Test circuits for continuity. Repair or replace.

JOB SHEET 1

HORN AND WASHER/WIPER SYSTEMS

VI

OBJECTIVE 11a

Inspect and service horns.

TOOLS AND EQUIPMENT

- Service manual
- Multimeter
- Jumper wires
- Test lamp
- Safety glasses
- Fender covers

PROCEDURE

1. Locate service manual test instructions. Follow service manual instructions through basic circuit tests.

2. Connect jumper wires from battery to horn and from horn to ground.

If it operates:	If it fails to operate:
a. Check circuit protection devices.	a. If service manual offers service procedures, follow those steps.
b. Test switch according to service manual procedures.	b. Replace motor (in some cases, service to the horn is recommended).
c. Test circuit continuity and check for faults.	

3. Have your instructor check your work.

4. Put away tools and materials and clean the work area.

JOB SHEET 2

HORN AND WASHER/WIPER SYSTEMS

VI

OBJECTIVE 11b **Inspect and repair wiper systems.**

TOOLS AND EQUIPMENT

- Service manual
- Multimeter
- Test lamp
- Fender covers
- Safety glasses

PROCEDURE

1. Locate and follow service manual procedures through all testing and servicing.
2. Check circuit protection devices.
3. Check all circuit connections.
4. Test for voltage entering wiper motor.
5. If wiper motor is receiving current:
    a. Check wiper motor grounds.
    b. If wipers still fail to operate properly, remove motor and bench test according to service manual procedures.

    If wiper motor is not receiving current:
    a. Test switch according to service manual procedures.
    b. Test circuit wiring for faults.
6. Have your instructor check your work.
7. Put away tools and materials and clean the work area.

JOB SHEET 3

HORN AND WASHER/WIPER SYSTEMS

VI

OBJECTIVE 11c **Inspect and service washer systems.**

TOOLS AND EQUIPMENT

- Service manual
- Water/washer fluid
- Test lamp
- Jumper wires
- Multimeter
- Fender covers
- Safety glasses

PROCEDURE

ELECTRIC

1. Locate and follow service manual procedures.
2. Check washer reservoir for fluid. Fill if necessary.
3. Check hoses and nozzles for pinches, kinks, clogs, or breaks.
4. Activate system and observe performance.
5. Test motor voltage.
    - a. If it is receiving proper voltage, replace motor.
    - b. If it is receiving improper voltage, test and service switch and wiring leading to motor.
6. Have your instructor check your work.
7. Put away tools and materials and clean the work area.

MECHANICAL

1. Follow procedures above to check hoses and nozzles.
2. If all components check out, test the diaphragm for ruptures.

PRACTICAL TEST 1

HORN AND WASHER/WIPER SYSTEMS

VI

JOB SHEET 1

Inspect and service horns.

STUDENT'S NAME ________________ DATE __________

EVALUATOR'S NAME ______________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Located and followed service manual instructions for basic tests.	_____	_____
2. Connected jumper wires from battery to horn and from horn to ground.		
If it operated:		
a. Checked circuit protection devices.	_____	_____
b. Tested switch according to service manual procedures.	_____	_____
c. Tested circuit continuity and checked for faults.	_____	_____
If it failed to operate:		
a. If service manual offered service procedures, followed those steps.	_____	_____
b. Replaced motor.	_____	_____
3. Used proper tools correctly.	_____	_____
4. Performed steps in a timely manner.	_____	_____
5. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
6. Provided satisfactory responses to questions asked.	_____	_____
7. Put away tools and materials and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Showed a thorough understanding of the circuit	4	3	2	1
Located and used service manual directions	4	3	2	1
Connected jumper wires from battery to horn and ground and made correct diagnosis	4	3	2	1
Located and checked all circuit protection devices	4	3	2	1
Tested switch according to service manual procedures	4	3	2	1
Tested circuit for continuity	4	3	2	1
Repaired or replaced as directed	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

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PRACTICAL TEST 2

HORN AND WASHER/WIPER SYSTEMS

VI

JOB SHEET 2

Inspect and repair wiper systems.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Located and followed service manual procedures throughout all testing and servicing.	_____	_____
2. Checked circuit protection devices.	_____	_____
3. Checked all circuit connections.	_____	_____
4. Tested for voltage entering wiper motor.	_____	_____
5. If wiper motor received current:		
a. Checked wiper motor grounds.	_____	_____
b. If wipers still failed to operate properly, removed motor and bench tested according to service manual procedures.	_____	_____
If wiper motor did not receive current:		
a. Tested switch according to service manual procedures.	_____	_____
b. Tested circuit wiring for faults.	_____	_____
6. Used proper tools correctly.	_____	_____

		YES	NO
7.	Performed steps in a timely manner.		
8.	Practiced safety rules throughout procedure.		
9.	Provided satisfactory responses to questions asked.		
10.	Put away tools and materials and cleaned work area.		

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Located and followed service manual procedures	4	3	2	1
Checked all circuit protection devices and connectors thoroughly	4	3	2	1
Tested voltage entering the wiper motor	4	3	2	1
Removed motor and bench tested	4	3	2	1
Tested switch according to service manual procedures	4	3	2	1

EVALUATOR'S COMMENTS

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

HORN AND WASHER/WIPER SYSTEMS

JOB SHEET 3

Inspect and service washer systems.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Located and followed service manual procedures.	_____	_____
2. Checked washer reservoir for fluid and filled if necessary.	_____	_____
3. Checked hoses and nozzles for pinches, kinks, clogs, or breaks.	_____	_____
4. Activated system and observed performance.	_____	_____
5. Tested motor voltage.		
a. If it was receiving proper voltage, replaced motor.	_____	_____
b. If it was receiving improper voltage, tested and serviced switch and wiring leading to motor.	_____	_____
6. Used proper tools correctly.	_____	_____
7. Performed steps in a timely manner.	_____	_____

	YES	NO
8. Practiced safety rules throughout procedure.	____	____
9. Provided satisfactory responses to questions asked.	____	____
10. Put away tools and materials and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Located and followed service manual procedures	4	3	2	1
Checked washer reservoir and filled	4	3	2	1
Checked hoses carefully and serviced blocks or breaks	4	3	2	1
Tested motor voltage according to service manual procedures	4	3	2	1
Removed and replaced motor	4	3	2	1
Tested and serviced switch and wiring	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

HORN AND WASHER/WIPER SYSTEMS

NAME ______________________________ SCORE ______

OBJECTIVE 1

List horn system components and horn assembly parts.

1. The horn system components are:

____

____

____

2. The horn assembly parts are:

____

____

____

____

OBJECTIVE 2

Complete statements about the operation of a horn.

1. Current flows to an ______________________________ that pulls on an ______________________ connected to the diaphragm.

2. As the diaphragm moves, ____________________ ________________ are pulled apart and the circuit is opened.

3. The electromagnet loses ____________________ (and thus magnetism) and the armature and diaphragm move back to their original place.

4. The contact points come ____________ ____________ ____________________ and the circuit is closed.

OBJECTIVE 3 **List components of the wiper system.**

____

____

____

____

____

OBJECTIVE 4 **Identify true statements about the operation of a wiper system.** Write an "X" in the blanks before true statements.

______1. Voltage is supplied from the alternator when the wiper switch is activated and the car is not running.

______2. Voltage is supplied from the battery to the wiper motor when the wiper switch is activated, grounding the circuit.

______3. Contacts located in the switch control current through or around resistors that adjust wiper speed.

______4. Brushes located in the motor determine the amount of voltage traveling from the motor to the linkage.

______5. The wiper motor shaft turns.

______6. The wiper motor transmission turns.

______7. The wiper motor transmission uses a series of gears to transform the rotations to a back-and-forth motion.

______8. The wiper linkage transfers the back-and-forth motion to the wiper blades.

______9. The wiper linkage provides current for the blades.

______10. If a pulse feature is included in the system, a control unit monitors voltage.

______11. If a pulse feature is included in the system, a circuit breaker opens and closes, turning the wipers off and on.

OBJECTIVE 5 **Describe the two types of wiper switches.**

____

____

____

____

____

____

____

____

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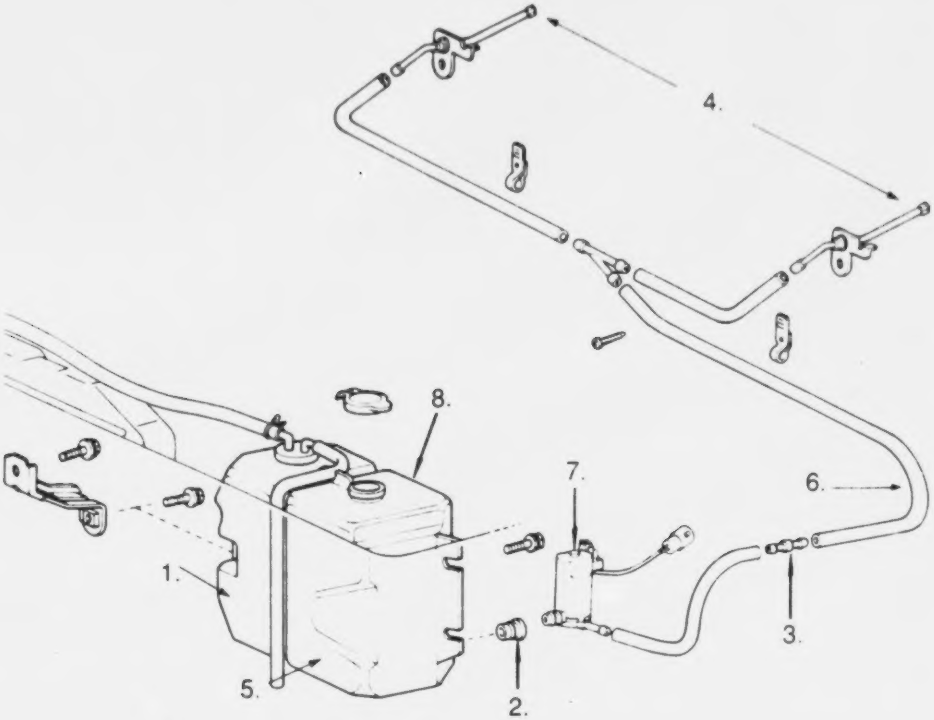
OBJECTIVE 6 **Label components of the washer system.**



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1. ____________

2. ____________

3. ____________

4. ____________

5. ____________

6. ____________

7. ____________

8. ____________

OBJECTIVE 7 **Describe the operation of the washer system.**

MECHANICAL

____

____

ELECTRIC

____

____

____

____

____

____

____

NOTICE The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.

OBJECTIVE 8	**Diagnose horn problems.**	SCORE ______
OBJECTIVE 9	**Diagnose wiper system problems.**	SCORE ______
OBJECTIVE 10	**Diagnose washer system problems.**	SCORE ______
OBJECTIVE 11a	**Inspect and service horns.**	RATING ______
OBJECTIVE 11b	**Inspect and repair wiper systems.**	RATING ______
OBJECTIVE 11c	**Inspect and service washer systems.**	RATING ______

WRITTEN TEST ANSWERS

HORN AND WASHER/WIPER SYSTEMS

VI

OBJECTIVE 1

1. Horn relay
   Switch
   Wiring

2. Coil
   Diaphragm
   Contacts
   Resistor
   Armature

OBJECTIVE 2

1. electromagnet
   armature
2. contact points
3. current
4. back into contact

OBJECTIVE 3

- Switch
- Wiper arms
- Wiper control circuit
- Wiper motor assembly
- Wiper linkage

OBJECTIVE 4

2, 3, 5, 7, 8, 10

OBJECTIVE 5

- Multi-function lever on the steering column with turning signals, wiper switch, and washer switch.

- Separate switch, either on the steering column or on the dash board, that controls only the washer/wiper system.

OBJECTIVE 6

1. Cooling system reservoir
2. Bushing
3. Joint
4. Washer nozzle
5. Washer solution reservoir
6. Hose
7. Washer motor/pump
8. Jar

OBJECTIVE 7 Discussion should include:

MECHANICAL

- When the washer switch is activated, the washer pump receives current.
- The magnet armature is pulled toward the coil.
- As the armature moves, the piston actuator plate is moved from in front of the piston spring.
- The piston spring is allowed to expand and contract, alternately drawing fluid from the reservoir and then forcing it to nozzles.

ELECTRIC

- When the washer switch is activated, the pump receives current.
- The armature spins and, in turn, spins the impeller, a fan-like blade.
- The fluid is pressurized and forced through the washer hoses and nozzles.

OBJECTIVE 8 Refer to Answers to Assignment Sheet 1.

OBJECTIVE 9 Refer to Answers to Assignment Sheet 2.

OBJECTIVE 10 Refer to Answers to Assignment Sheet 3.

OBJECTIVE 11 Refer to Practical Tests for Job Sheets 1 - 3.

OBJECTIVE SHEET

MOTORIZED ACCESSORIES

VII

INTRODUCTION

Power windows, sunroofs, and rear window defoggers used to be luxuries, but today they are found on even the most inexpensive cars. As they continue to be included on more and more models, the need for service technicians to be able to service them becomes increasingly important.

UNIT OBJECTIVE

After completing this unit, the student should be familiar with the functions, servicing, and repair of most motorized accessory circuits. The student will demonstrate these competencies by completing assignment sheets, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. State general principles of motorized accessories.
2. Complete statements about the tailgate window circuit.
3. Select from a list true statements about power window circuits.
4. Discuss power seat circuits.
5. Arrange in order rear window defogger circuit procedure.
6. Distinguish among power lock circuit functions.
7. Complete statements about electric sunroof circuits.
8. Distinguish between interior and exterior electric mirror circuits.
9. Diagnose motorized tailgate problems. (Assignment Sheet 1)
10. Diagnose power window circuit component problems. (Assignment Sheet 2)
11. Diagnose power seat problems. (Assignment Sheet 3)
12. Diagnose defogger circuit problems. (Assignment Sheet 4)
13. Diagnose power lock problems. (Assignment Sheet 5)
14. Diagnose sunroof circuit problems. (Assignment Sheet 6)

15. Diagnose electric mirror problems. (Assignment Sheet 7)

16. Demonstrate the ability to:

    a. Inspect and service motorized tailgate window system. (Job Sheet 1)

    b. Inspect and service power window circuits. (Job Sheet 2)

    c. Inspect and service power seat circuits. (Job Sheet 3)

    d. Inspect and service defogger circuit problems. (Job Sheet 4)

    e. Inspect and service power lock circuits. (Job Sheet 5)

    f. Inspect and service sunroof circuit problems. (Job Sheet 6)

    g. Inspect and service electric mirror circuits. (Job Sheet 7)

SUGGESTED ACTIVITIES

MOTORIZED ACCESSORIES

VII

PREPARATION

- Review unit and plan presentation.
- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.
- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.
- Review teaching suggestions and plan classroom activities.
- Determine how you will schedule time for students to demonstrate competence in the required procedures.
- Order materials to supplement unit.

DELIVERY

Objective 1 State general principles of motorized accessories.

- Have students list all the motorized accessories they can think of. Have them add to the list as they complete work on the unit.
- Have students complete Activity Sheet 1.
- Have students discuss other accessories they think will become standard. Decide which are motorized accessories and which are not.

Objective 2 Complete statements about the tailgate window circuit.

- Have students compare several different cars tailgate/trunk electrical systems.
- Discuss the high brake auxiliary in newer model cars.
- Have students complete Assignment Sheet 1 and Job Sheet 1.

Objective 3 Select from a list true statements about power window circuits.

- Have students complete Assignment Sheet 2 and Job Sheet 2.
- Have students compare tailgate and power window circuits.
- Have students compare two-and four-door circuits.

Objective 4 Discuss power seat circuits.

- Have students complete Assignment Sheet 3 and Job Sheet 3.
- Have students adjust power seats and identify the motors they used.

Objective 5 Arrange in order rear window defogger circuit procedure.

- Have students complete Assignment Sheet 4 and Job Sheet 4.
- Have students compare rear window defogger and windshield defogger.

Objective 6 Distinguish among power lock circuit functions.

- Have students complete Assignment Sheet 5 and Job Sheet 5.
- Have a repair technician or locksmith discuss automatic locking systems. Be sure they discuss damage to the system that may occur if the lock is opened mechanically, as sometimes happens when keys are locked in a car.
- Compare security and locking systems.

Objective 7 Complete statements about electric sunroof circuits.

- Have students complete Assignment Sheet 6 and Job Sheet 6.
- Allow students who have not operated a sunroof to do so.
- Discuss service manual instructions for sunroofs. Point out to the class that many of these repairs are mechanical rather than electrical in nature.

- Have students compare sunroofs and windows.

Objective 8 Distinguish between interior and exterior electric mirror circuits.

- Have students complete Assignment Sheet 7 and Job Sheet 7.
- Have students compare day and night driving using a regular and automatic rear-view mirror.
- Have students activate sensors to make automatic rear view mirror "flip" to night vision.

APPLICATION

Objective 9 Diagnose motorized tailgate problems.
Objective 10 Diagnose power window circuit component problems.
Objective 11 Diagnose power seat problems.
Objective 12 Diagnose defogger circuit problems.
Objective 13 Diagnose power lock problems.
Objective 14 Diagnose sunroof circuit problems.
Objective 15 Diagnose electric motor problems.

- Have students use and trace schematics of all front and/or rear end electrical circuits.
- Have students compare servicing steps and diagnosis procedures between these assignment sheets, and between these sheets and other circuits. Have them discuss similarities and differences.
- Have students complete Assignment Sheets 1-7.
- Have students complete Job Sheets 1-7.

Objective 16 Demonstrate the ability to:

a. Inspect and service motorized tailgate window system. (Job Sheet 1)
b. Inspect and service power window circuits. (Job Sheet 2)
c. Inspect and service power seat circuits. (Job Sheet 3)
d. Inspect and service defogger circuit problems. (Job Sheet 4)
e. Inspect and service power lock circuits. (Job Sheet 5)
f. Inspect and service sunroof circuit problems. (Job Sheet 6)
g. Inspect and service electric mirror circuits. (Job Sheet 7)

- Try to allow students to compare systems between makes and models.
- Have students note other systems connected in circuit and their possible role in diagnosis.
- Compare self-diagnostic tests available.

EVALUATION

Pretest

- Pretest qualifying students.
- Determine individual requirements from pretest results.
- Counsel students individually on pretest results and study requirements.
- Modify materials in unit or create supplementary materials for individual students as required.

Practical test

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.
- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.
- Complete appropriate section of competency profiles.

- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Publications

- *Power Sunroof/Vista Vent, and T-Top Waterleak Correction* — Camero and Firebird are offered by General Motors. Operations, on-and off-car service, diagnostic techniques, and leak/seal information are included. Order through:

  General Motors Training
  Material Merchandising
  Kent-Moore Tool and Equipment Division
  SPX Corporation
  28635 Mound Rd.
  Warren, MI 48092
  1-800-468-6657

Media

- *Electronics for Auto Technicians.* Five ½" VHS cassettes, Bergwall Productions, 1991. Series is designed for use in ASE certification programs and correlates with NATEF Task List criteria. Series subjects cover *Understanding Resistors, Inductors/Capacitors, Understanding Semiconductors, Understanding Transistors, and Integrated Circuits.* Order No. A30-V11, available from Bergwall Productions, P.O. Box 238, Garden City, NY 11530-0238, phone 1-800-645-3565. Also available in single tapes. Also listed in *Cambridge Vocational and Technical Catalog.*

- *The Computer in the Automobile: Systems and Components.* Five-part filmstrip, 74 min., and Teacher's Guide. Includes Evolution and applications, the system and its components, integrated circuits: the computer's brain, test equipment, and on-board computer vocabulary. Order No. 31180-127, available from Vocational Media Association, 1-800-411-1242.

UNIT REFERENCES

- *1988 Celebrity Electrical Diagnosis Service Manual Supplement.* General Motors, 1988.

- *1989 Prelude Service Manual.* Honda Motor Co., Ltd., 1988.

- *C/K Pickup Electrical Diagnosis and Wiring Diagrams.* General Motors, 1989.

- *Electrical Service and Repair Domestic Cars, 1987 Supplement.* San Diego, California: Mitchell International, Inc., 1987.
- Mackert, Howard C. *Automotive Mechanics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1988.

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel the student individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions.

Objective	Questions
1	1-2
2	3-5
3	6-8
4	9-10
5	11-12
6	13-14
7	15-17
8	18-19
9	20-21
10	22
11	23
12	35
13	24-25
14	26-27
15	28-29
16	30-38

ANSWER KEY

1. b
2. c
3. b
4. c
5. a
6. a
7. b
8. a
9. c
10. c
11. a
12. b
13. a
14. b
15. b
16. c
17. b
18. a
19. c
20. a
21. b
22. b
23. c
24. a
25. c
26. a
27. b
28. a
29. c
30. c
31. c
32. a
33. c
34. c
35. a
36. b
37. a
38. c

PRETEST

MOTORIZED ACCESSORIES

VII

NAME ______________________________ SCORE ______

______1. Motorized accessories are ___.

a. important components of any car
b. not necessary for operation of the car
c. always linked to the car's computer

______2. Motorized accessories are ___.

a. electrical
b. electronic
c. electrical but may include electronic components

______3. Rear window circuits include the battery and ___.

a. headlight switch
b. ignition switch wiring
c. alternator

______4. When current flows through the rear window circuit, one terminal is grounded and the other ___.

a. is protected by a circuity breaker
b. receives heavy current
c. feeds current to the motor

______5. The rear window is raised or lowered depending upon ___.

a. polarity
b. voltage
c. resistance

______6. Power window components include the ___.

a. driver and passenger switches, driver and passenger motors, and a power window relay
b. battery, a driver switch, driver and passenger motors, and an integrated circuit
c. alternator, a driver motor, driver and passenger motors, and sensors

______7. The power window motor runs when ___.

a. a switch is pushed
b. the ignition is in ON and a switch is pushed
c. the ignition is in ON and a rheostat is activated

______8. When the driver's master switch is activated, voltage is applied to ___.

a. any of the motors
b. all switches
c. an integrated circuit

______9. Power seats are manipulated by ___.

a. one motor
b. two motors
c. up to three motors

_____10. The direction of the seat's movement is determined by ___.

a. voltage
b. resistance
c. polarity

_____11. The rear window defogger timer ___.

a. activates the defogger and defogger indicator telltale
b. allows the driver to determine how long the defogger will run
c. activates a back seat heater

_____12. When the rear window defogger switch is activated, current flows to a rear window defogger ___.

a. control unit
b. timer unit
c. outlet

_____13. Power locks allow the driver to ___.

a. control all door locks
b. control all front seat locks
c. unlock, but not lock, all doors

_____14. The automatic door lock relay detects ___.

a. whether the doors are locked or unlocked
b. which terminal receives voltage and which is grounded
c. the amount of resistance in the circuit

_____15. The sunroof circuit includes ___.

a. a switch, two motors, and a control unit
b. a switch, a motor, and a relay
c. a switch, a motor, a control unit, and a relay

_____16. Sunroofs are controlled by a reversible motor located ___.

a. just behind the sunroof
b. alongside the sunroof
c. in the roof of the car

_____17. The sunroof is pulled open or closed with a ___

a. chain and sprocket
b. cam and drive cables
c series of gears

_____18. The position of automatic mirrors is controlled by ___.

a. two motors
b. a motor and a relay
c. a motor with a belt drive

_____19. Automatic rear-view mirrors "flip" for nighttime driving if proper lighting is registered by sensors on the ___.

a. front of the mirror
b. back of the mirror
c. front and back of the mirror

_____20. The two tailgate switches are located at the ___.

a. dashboard and tailgate
b. doorjamb and dashboard
c. doorjamb and tailgate

_____21. If a tailgate window cannot be controlled by the dashboard switch but can be by the other switch, the fault is in the ___.

a. dashboard switch
b. dashboard switch or wiring leading to it
c. dashboard switch, wiring leading to it, or dashboard doorjamb.

_____22. Three important tests when servicing malfunctioning power windows are ___.

a. master control switch test, window control switch test, and window relay test
b. master control switch test, window control switch test, and window motor test
c. master control switch test, window relay test, and window motor test

_____23. Power seat performance can be affected by all of these EXCEPT ___.

a. trash under the seat
b. a low battery
c. humidity level

_____24. The power door lock is connected in circuit to the ___.

a. courtesy light system
b. ignition switch
c. alternator

_____25. Two- and four-door power lock systems are ___.

a. very different
b. identical
c. similar

_____26. Sunroof repairs often center on ___.

a. adjustment, seals, and proper fit of the window
b. faulty sunroof motors
c. sunroof shorts caused by rain

_____27. The first thing to test when servicing sunroofs is the ___.

a. motor for continuity
b. connectors in the circuit
c. switch

_____28. Exterior motorized mirrors can be affected by ___.

a. a blown fuse
b. a short in the ignition switch
c. a fault in the headlight switch

_____29. Interior motorized rear-view mirrors "flip" for night driving when ___.

a. a clock in the logic center says it is late enough in the day
b. a driver switch is activated
c. light sensors sense bright light on one side of the mirror and dim light on the other

_____30. If a tailgate window will not respond to a dashboard or tailgate switch, you should test for ___.

a. shorts in dashboard switch
b. problems in the CPU
c. problems in the motor or circuit breaker

_____31. If a tailgate window will open with the dashboard switch, but not the tailgate switch, test the ___.

a. motor
b. relay
c. tailgate switch

_____32. When testing power windows, test ___.

a. circuit breakers before switches
b. motors before circuit breakers
c. switches before circuit breakers

_____33. When power seat problems are accompanied by a dimming dome light ___.

a. power seat circuits have shorted into dome light circuits
b. a common circuit breaker may have blown
c. the seats may be jammed

______34. Power seat motors should be ___.

a. tested with a voltmeter
b. removed and connected directly to a battery for testing
c. tested and then the leads reversed and retested

______35. Window defogger voltage should be ___.

a. consistent with service manual specs
b. minimal
c. checked with an ohmmeter

______36. One door lock problem service technicians see often is ___.

a. defective door lock motors
b. bad grounds at the door lock relay
c. shorts at the door lock switches

______37. Sunroof service sometimes requires removal of the ___.

a. headliner
b. windshield
c. door assembly

______38. To test an exterior mirror, remove the ___.

a. mirror
b. dash switch
c. door trim

MOTORIZED ACCESSORIES

OBJECTIVE 1

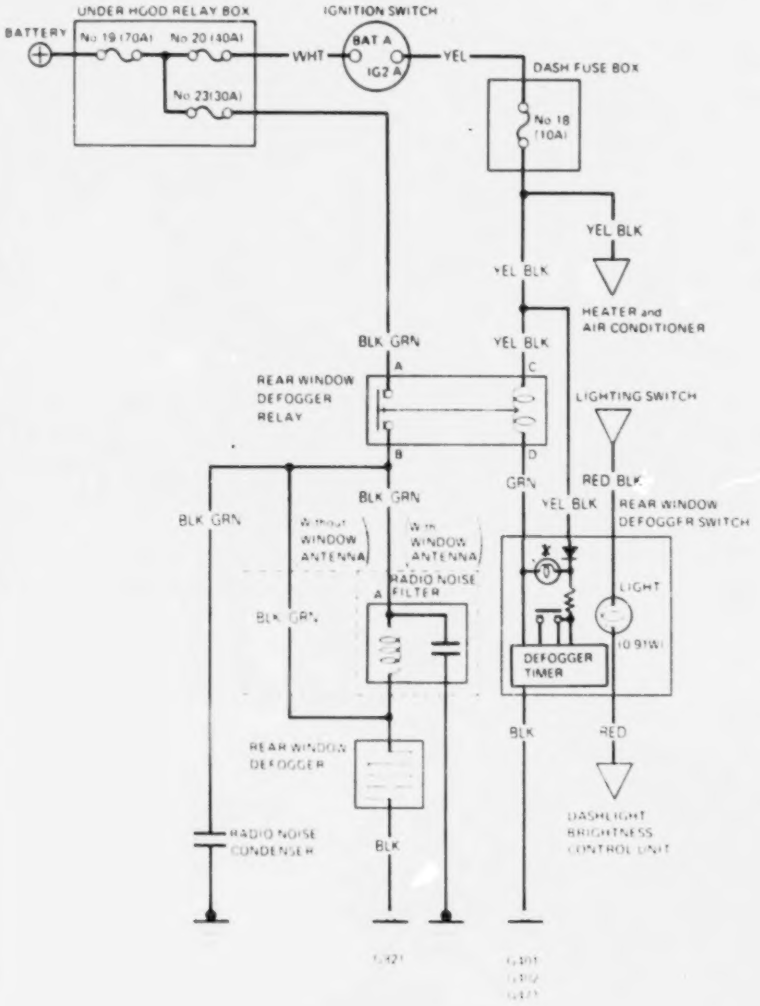
State general principles of motorized accessories.

- They are not necessary for operation of the car and are usually comfort or convenience features.
- They all use a motor, usually (but not always) to move something.
- They are electrical but may include electronic circuitry or be connected to the CPU.

NOTE: Check all components during all electrical tests for looseness. This procedure is called the wiggle test. Just wiggle each component to see if it comes loose. Look at grounds and connections.

OBJECTIVE 2

Complete statements about the tailgate window circuit.

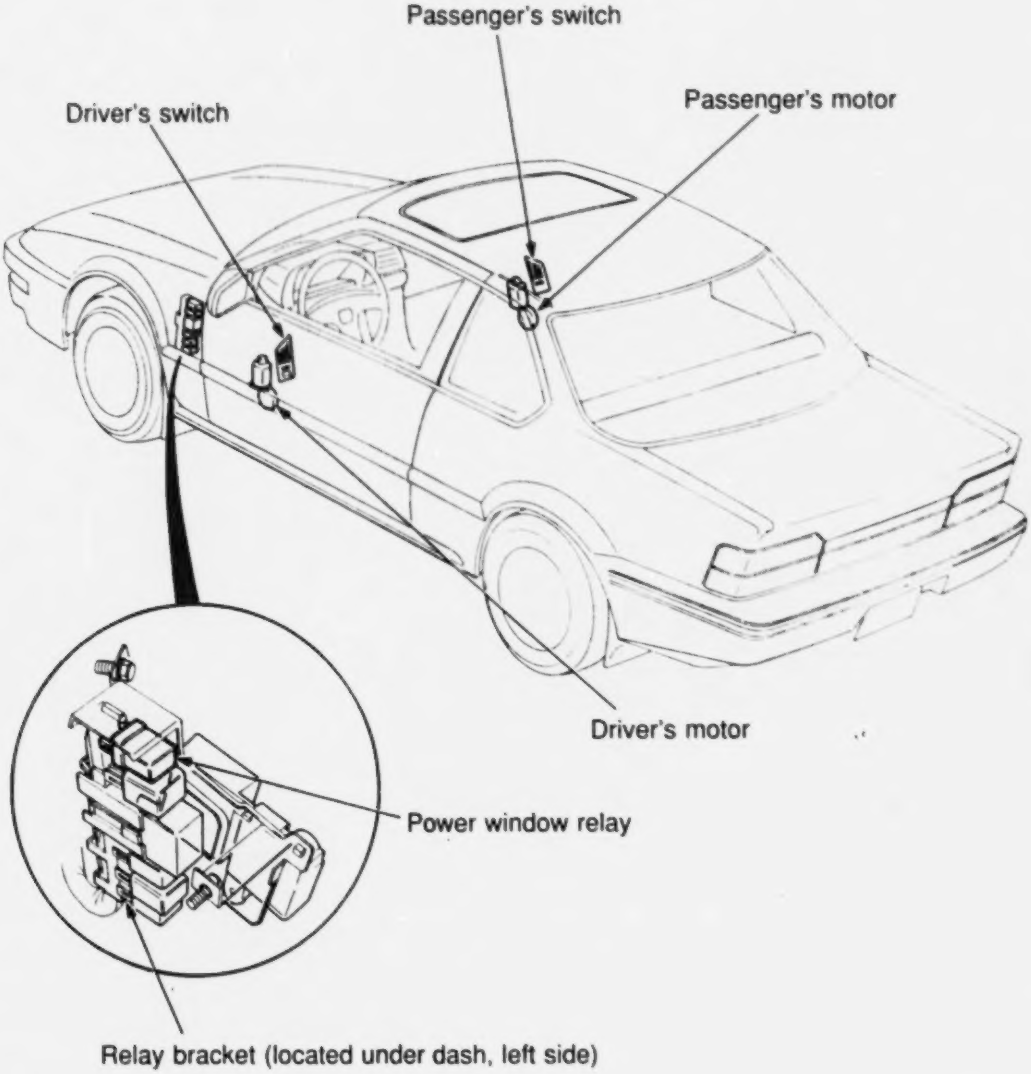

UNDER HOOD RELAY BOX
BATTERY
No 19 (70A)
No 20 (40A)
No 23 (30A)
WHT
IGNITION SWITCH
BAT A
IG2 A
YEL
DASH FUSE BOX
No 18 (10A)
YEL BLK
YEL BLK
HEATER and AIR CONDITIONER
BLK GRN
YEL BLK
A
C
REAR WINDOW DEFOGGER RELAY
LIGHTING SWITCH
B
D
GRN
RED BLK
BLK GRN
YEL BLK
REAR WINDOW DEFOGGER SWITCH
BLK GRN
Without WINDOW ANTENNA
With WINDOW ANTENNA
RADIO NOISE FILTER
A
BLK GRN
LIGHT
(0.91W)
DEFOGGER TIMER
BLK
RED
REAR WINDOW DEFOGGER
DASHLIGHT BRIGHTNESS CONTROL UNIT
RADIO NOISE CONDENSER
BLK
G321
G401

Used with permission of American Honda Company.

- Rear tailgate window components include the battery and ignition switch wiring. A rear window defogger, radio speakers and other radio components, rear brake lights, signal light, motorized latch, and heater/air conditioner circuitry may be housed in the tailgate.

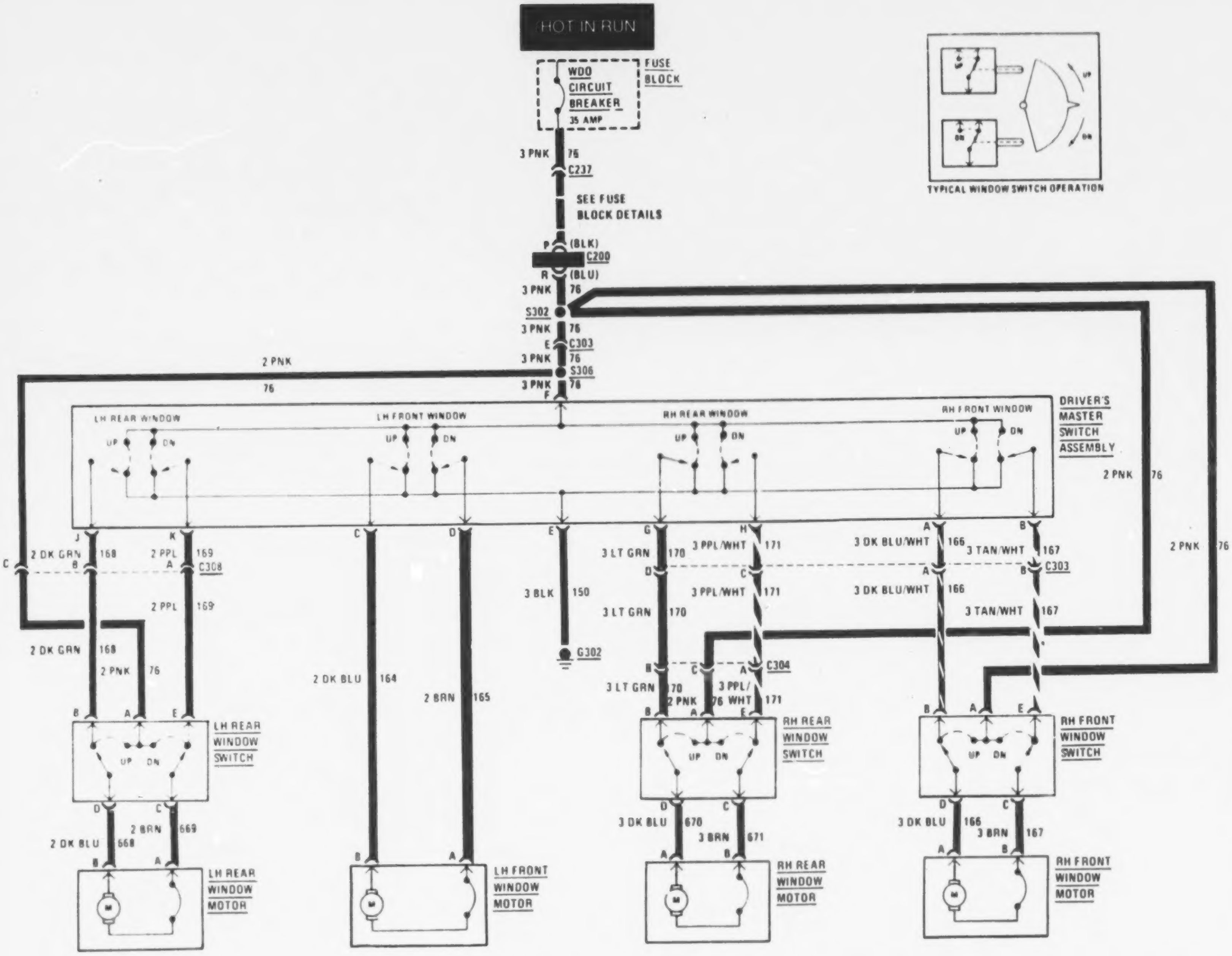
- Rear windows operate like any power window. When current flows through the circuit, one terminal is a ground and the other feeds current to the motor. Reversing the terminals reverses the polarity. Depending upon the polarity, the window is raised or lowered.

OBJECTIVE 3 **Select from a list true statements about power window circuits.**


Passenger's switch
Driver's switch
Passenger's motor
Driver's motor
Power window relay
Relay bracket (located under dash, left side)

Used with permission of American Honda Company.

- Components
    - Driver's switch
    - Driver's motor
    - Passenger's switch
    - Passenger's motor
    - Power window relay


HOT IN RUN
WDO CIRCUIT BREAKER 35 AMP
FUSE BLOCK
3 PNK 76
C237
SEE FUSE BLOCK DETAILS
P (BLK)
C200
R (BLU)
3 PNK 76
S302
3 PNK 76
E C303
3 PNK 76
S306
3 PNK 76
F
2 PNK
76
LH REAR WINDOW
LH FRONT WINDOW
RH REAR WINDOW
RH FRONT WINDOW
UP
DN
DRIVER'S MASTER SWITCH ASSEMBLY
2 PNK 76
J
K
C
D
E
G
H
A
B
C
2 DK GRN 168
2 PPL 169
C308
3 LT GRN 170
3 PPL/WHT 171
3 DK BLU/WHT 166
3 TAN/WHT 167
C303
3 BLK 150
G302
2 PPL 169
2 DK GRN 168
2 PNK 76
2 DK BLU 164
2 BRN 165
C304
3 LT GRN 170
2 PNK 76
3 PPL/WHT 171
LH REAR WINDOW SWITCH
RH REAR WINDOW SWITCH
RH FRONT WINDOW SWITCH
2 DK BLU 668
2 BRN 669
3 DK BLU 670
3 BRN 671
3 DK BLU 166
3 BRN 167
LH REAR WINDOW MOTOR
LH FRONT WINDOW MOTOR
RH REAR WINDOW MOTOR
RH FRONT WINDOW MOTOR
M
TYPICAL WINDOW SWITCH OPERATION

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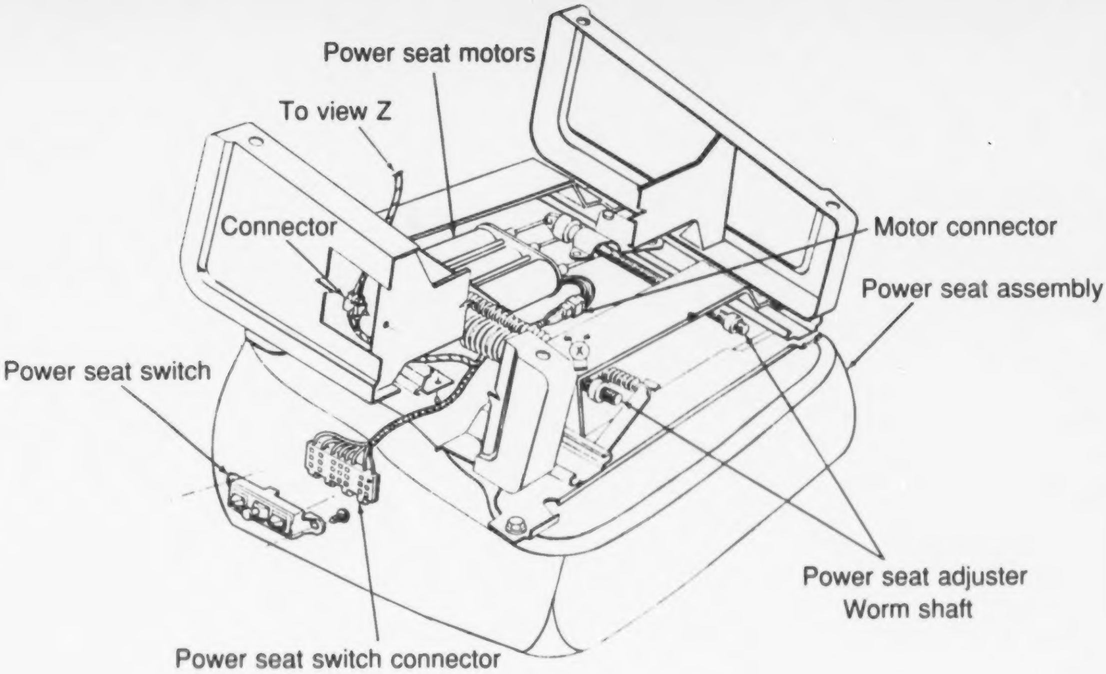
BEST COPY AVAILABLE

- How the circuit works:
  - When the ignition is in ON, current is supplied to the switches.
  - When a switch is pushed to the UP position, the circuit is completed and the window motor runs.
  - When the switch is released, the connection is broken and the motor stops.
  - When the switch is pushed to the DOWN position, the second wire between the switch and motor becomes the pathway for the current and polarity is reversed. This causes the motor to run in the opposite direction, and the window is lowered.
  - All windows may be controlled by the driver's master switch.

    NOTE: Some systems include lock-out switches. These switches are located in the Driver's Switch console and, when activated, windows can only be raised or lowered from the Driver's Switch.

OBJECTIVE 4 **Discuss power seat circuits.**

- Up to three motors may be used:
  - Front Height Motor
  - Rear Height Motor
  - Forward Back Motor


Power seat motors
To view Z
Connector
Motor connector
Power seat assembly
Power seat switch
Power seat adjuster Worm shaft
Power seat switch connector

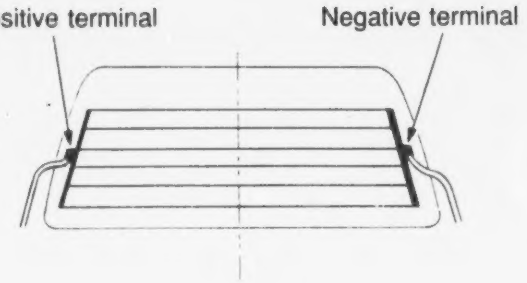
Used with permission of Chrysler Corporation.

- The height of the front and back of the seat are controlled by two different motors. The entire seat is moved when both motors are activated by pushing the UP or DOWN buttons. The direction of movement is changed by reversing the motor's polarity.
- The horizontal position of the seat is controlled by the Forward Back Motor. Putting the seat's switch in FORWARD activates the motor and the seat moves forward. Putting the switch in BACK, reverses the motor's polarity and the seat moves backwards.

NOTE: Some systems combine power seats and computer memory. A driver can position the seat and program the computer to readjust the seat to that position any time he or she drives the car.

OBJECTIVE 5

Arrange in order rear window defogger circuit procedure.



Used with permission of American Honda Company.

1. The ignition is in ON.

2. Voltage is applied to the rear window defogger switch.

3. When the switch is activated, current flows to a rear window defogger timer unit.

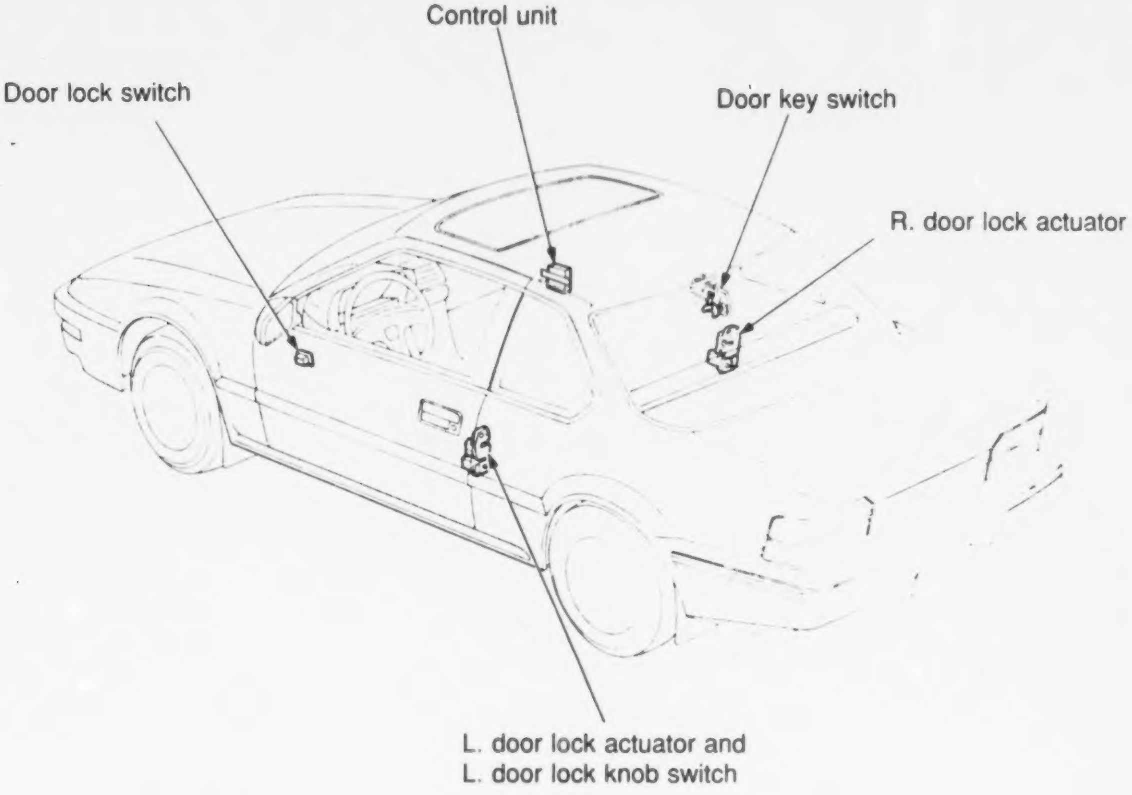
4. The defogger timer activates the defogger and the defogger indicator telltale.

5. The timer limits the how long the defogger runs.

   NOTE: The first time the defogger is turned on after the ignition is activated, it usually runs for 10 minutes. Each time the defogger switch is depressed after that, it will be limited to a 5-minute cycle.

   NOTE: In some cars, the rear window defogger is connected to power mirrors. When the rear window defogger is activated, a heating element in the mirror is also activated.

OBJECTIVE 6 **Distinguish among power lock circuit functions.**


Control unit
Door lock switch
Door key switch
R. door lock actuator
L. door lock actuator and
L. door lock knob switch

Used with permission of American Honda Company.

- Components:
  - Door Lock Switch
  - Control Unit
  - Door Key Switch
  - Door Lock Motor
- When using key from outside:
  - All doors will lock when any one door is locked.

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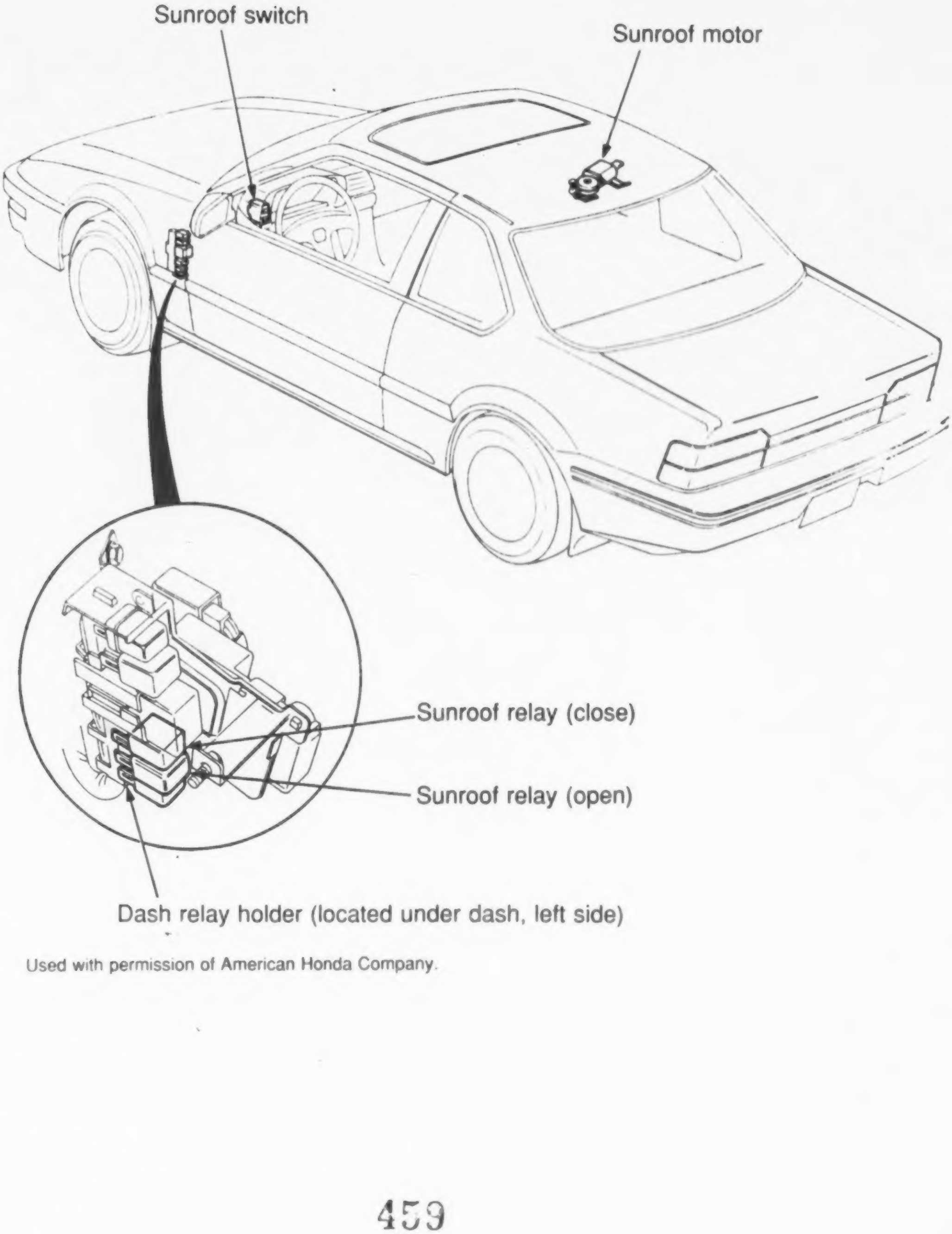
  - Driver's door will unlock when any other door is unlocked.
  - In some cases, all doors will unlock when any door is unlocked.
- When inside the car:
  - All doors can be locked or unlocked from the driver's door.
  - A lock-out feature prevents passenger locks from working, unless activated at the driver master switch.
- The door lock motor receives voltage traveling through a relay. The relay determines which terminal receives voltage and which is grounded. The reversal of voltage and grounding reverses motor operation.

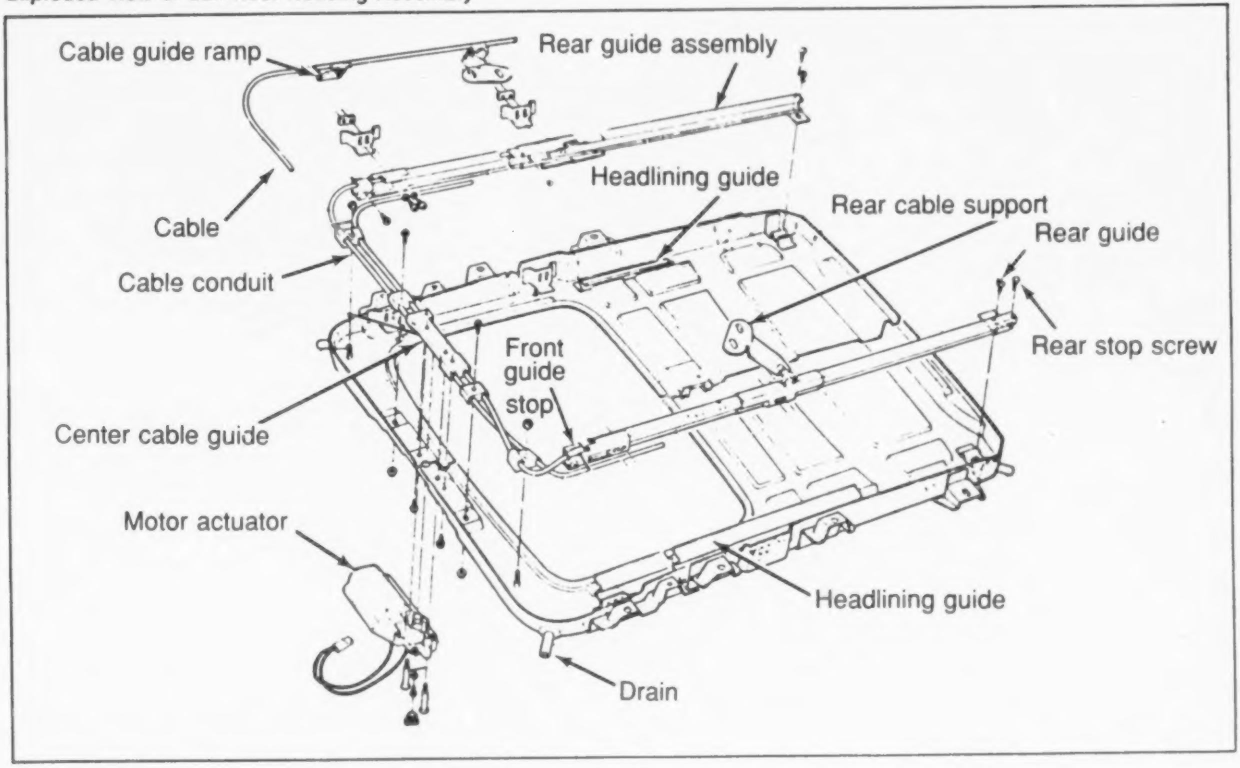
OBJECTIVE 7 **Complete statements about electric sunroof circuits.**


Sunroof switch
Sunroof motor
Sunroof relay (close)
Sunroof relay (open)
Dash relay holder (located under dash, left side)

Used with permission of American Honda Company.

- Components:
  - Switch
  - Motor
  - Relay
- Sunroofs are controlled by a reversible motor located in the roof of the car.
- A cam and drive cables pull the sunroof open or shut.
- Sunroofs can also be operated manually with a hand crank.

Exploded View of Sun Roof Housing Assembly


Cable guide ramp
Rear guide assembly
Headlining guide
Rear cable support
Rear guide
Cable
Cable conduit
Rear stop screw
Front guide stop
Center cable guide
Motor actuator
Headlining guide
Drain

Used with permission of Mitchell International.

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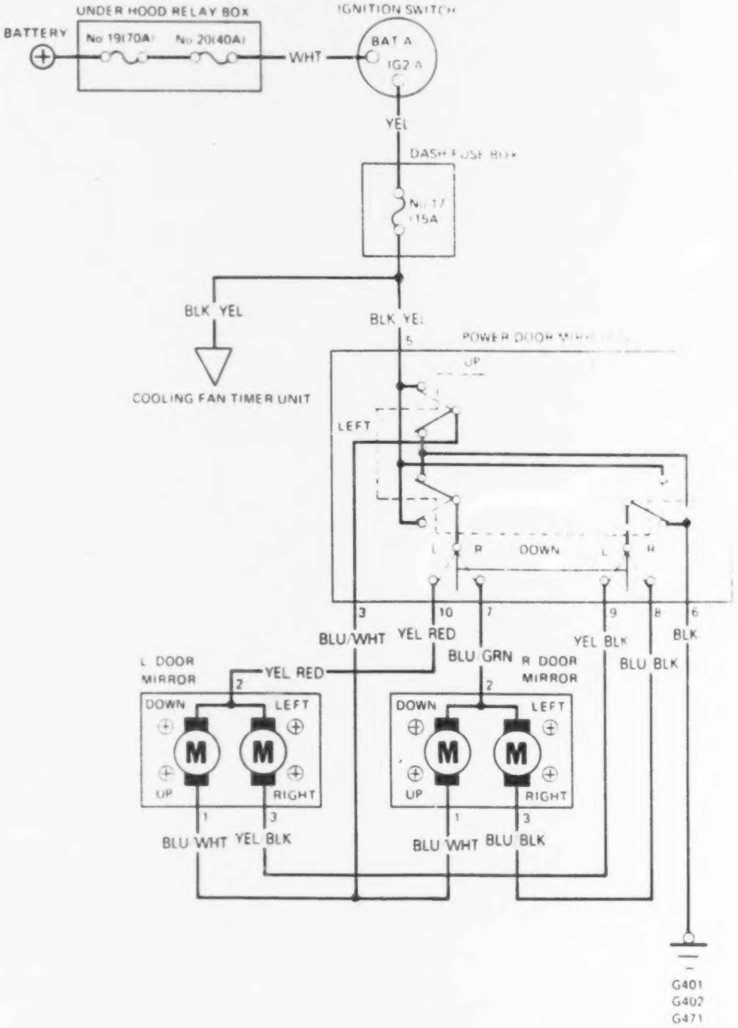
OBJECTIVE 8

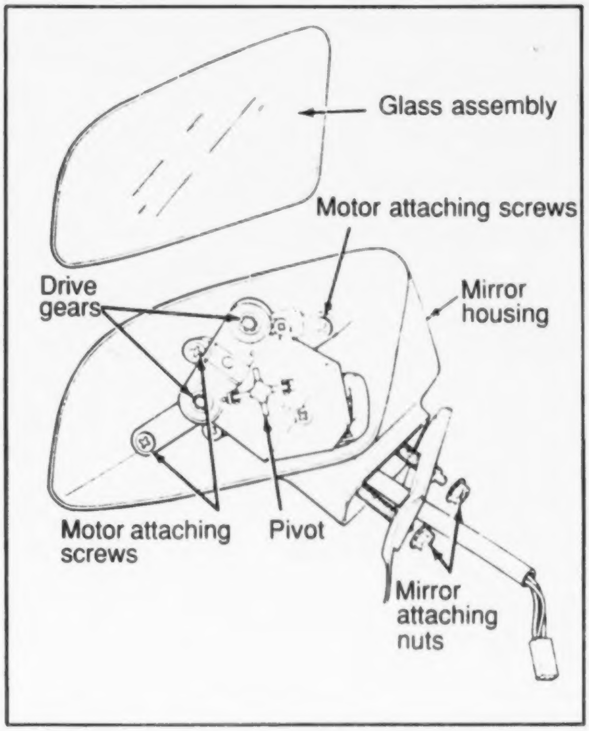
Distinguish between interior and exterior electric mirror circuits.

Exterior mirrors

- Two motors control the tilt of exterior mirrors. One controls the horizontal tilt, and one the vertical.
- A switch in the dashboard or console allows the driver to designate which mirror is to be adjusted and to make the adjustments.


UNDER HOOD RELAY BOX
BATTERY
No 19(70A)
No 20(40A)
WHT
IGNITION SWITCH
BAT A
IG2 A
YEL
DASH FUSE BOX
No 17
15A
BLK YEL
BLK YEL
COOLING FAN TIMER UNIT
5
POWER DOOR MIRROR
UP
LEFT
L
R
DOWN
L
R
3
10
7
9
8
6
BLU/WHT
YEL RED
BLU GRN
YEL BLK
BLK
BLU BLK
L DOOR MIRROR
YEL RED
2
R DOOR MIRROR
2
DOWN
LEFT
M
M
UP
RIGHT
DOWN
LEFT
M
M
UP
RIGHT
1
3
1
3
BLU WHT
YEL BLK
BLU WHT
BLU BLK
G401
G402
G471

Used with permission of American Honda Company.


Glass assembly
Motor attaching screws
Drive gears
Mirror housing
Motor attaching screws
Pivot
Mirror attaching nuts

Used with permission of General Motors Corporation.

Interior mirrors

- In some cars, a rear-view mirror adjusts automatically to reduce nighttime glare.
- Two sensors measure light hitting the front and back of the mirror and adjustments are made to equalize the two.

DEFOGGER TROUBLESHOOTING CHART

NOTE: The numbers in the table show the troubleshooting sequence.

Item to be inspected Symptom	Blown indicator light bulb	Blown No. 18 (10 A) fuse (in the dash fuse box)	Defogger switch input	Blown No. 23 (30 A) fuse (in the under-hood relay box)	Defogger relay	Broken defogger wire	Function Test	Poor ground	Open circuit in wires or loose or disconnected terminals
Defogger operates, but indicator light does not go on.	1								
Defogger does not operate and indicator light does not go on.		1	2					G401 G402 G471 G821	YEL/BLK or GRN
Defogger does not operate, but indicator light goes on.				1	3	4	2	G821	GRN or BLK/GRN
Operation time is too long or too short (Normal operation time is 20–30 minutes).			1						

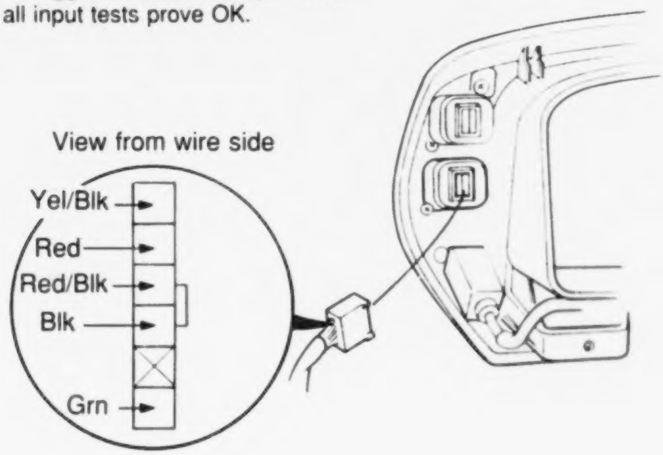
Used with permission of American Honda Company.

DEFOGGER SWITCH INPUT TEST

Remove the instrument panel. Disconnect the 6-P connector from the defogger switch.

Make the following input tests at the harness pins.

NOTE: Recheck the connections between the 6-P connector and the defogger switch, then replace the defogger switch if all input tests prove OK.



Used with permission of American Honda Company.

No.	Wire	Test condition	Test: desired result	Possible cause (If result is not obtained)
1	BLK	Under all conditions.	Check for continuity to ground; should be continuity.	• Poor ground (G401,402,471) • An open in the wire
2	YEL/BLK	Ignition switch ON.	Check for voltage to ground; should be battery voltage.	• Blown No. 18 (10 A) fuse • An open in the wire
3	GRN	Connect the GRN terminal to the BLK terminal with a jumper wire ignition switch ON.	Check for voltage between the defogger positive terminal to ground: should be battery voltage.	• Blown No. 23 (30 A) fuse • Faulty defogger relay • An open in the wire
4	RED/BLK and RED	Lighting switch ON and dashlight brightness control dial on full bright.	Check for voltage between RED/BLK and RED terminals: should be battery voltage.	• Faulty dashlight brightness control system • An open in the wire

REAR WINDOW DEFOGGER

Function Test

CAUTION: Be careful not to scratch or damage the defogger positive wire with the tester probe end.

1. Check for voltage between the positive terminal and body ground with the ignition switch and the defogger switch ON. There should be battery voltage.
   - If there is battery voltrage, go to step 2.
   - If there is no voltage, check for:
     - — Faulty defogger relay.
     - — An open in the BLK/GRN or GRN wire.
   - If relay and wiring are OK, go to switch input test.
2. Check for continuity between the negative terminal and body ground. If no continuity, check for open in the defogger ground wire.
3. Lightly touch the voltmeter positive probe to the center of each defogger wire, and the negative probe to the negative terminal. There should be approximately 6 V with the ignition switch and the defogger switch ON.
   - If the voltage is as specified, the defogger wire is OK.
   - If there is battery voltage, the defogger wire is broken in the negative side of the center.
   - If there is no voltage the defogger wire is broken in the positive side of the center.

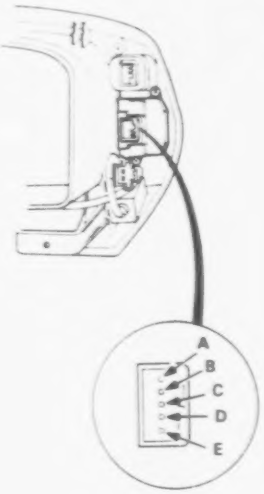
Used with permission of American Honda Company.

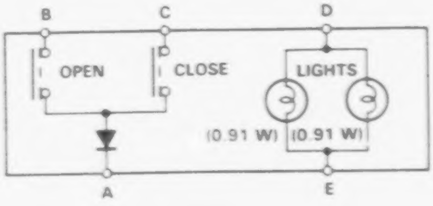
Switch Test

NOTE: For the switch and its bulbs replacement, see page 23-224.

1. Remove the instrument panel from the meter visor.
2. Check for continuity between the terminals in each switch position according to the table.

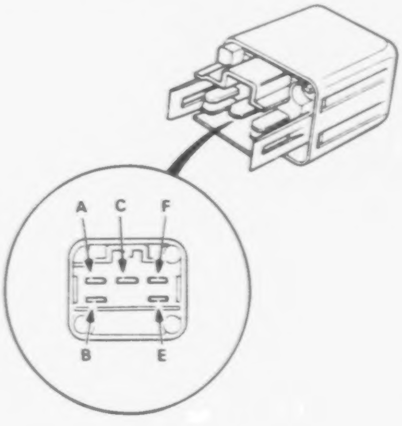
Terminal / Position	A		B	C	D		E
OFF					○		○
OPEN	○		○				
CLOSE				○			

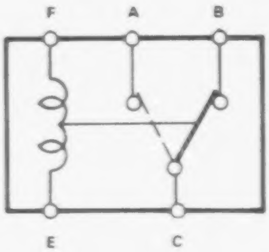




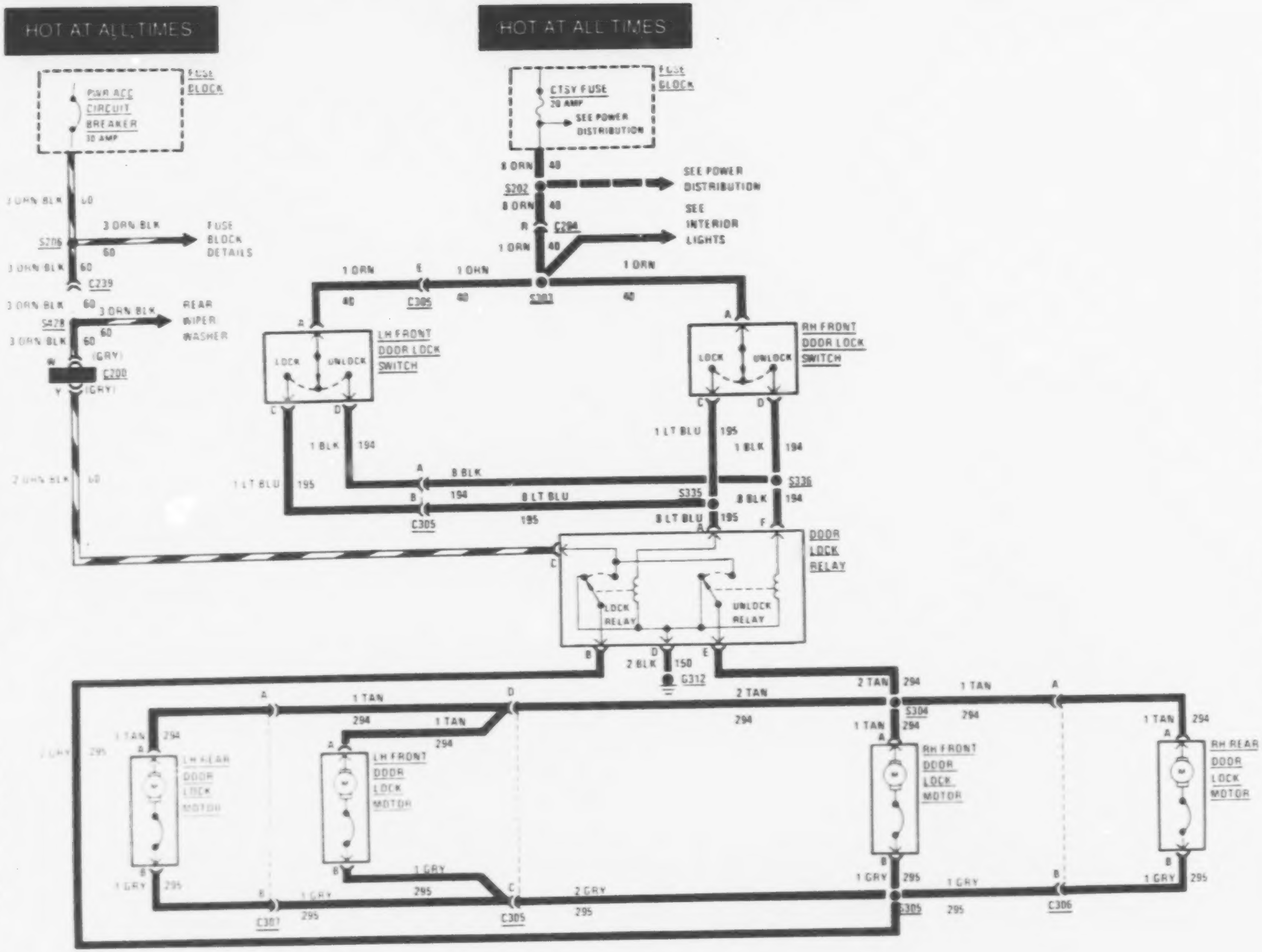
Relay Test

1. Remove the sunroof relays in the dash relay holder.
2. There should be continuity between the A and C terminals when the battery is connected to the E and F terminals.
   There should be continuity between the B and C terminals when the battery is disconnected.





Used with permission of American Honda Company.


HOT AT ALL TIMES
HOT AT ALL TIMES
FUSE BLOCK
PWR ACC CIRCUIT BREAKER 30 AMP
FUSE BLOCK
CTSY FUSE 20 AMP
SEE POWER DISTRIBUTION
8 ORN 40
S202
SEE POWER DISTRIBUTION
8 ORN 40
C294
SEE INTERIOR LIGHTS
1 ORN 40
3 ORN BLK 60
S206
3 ORN BLK
FUSE BLOCK DETAILS
C239
S428
REAR WIPER WASHER
(GRY)
C200
2 ORN BLK 60
1 ORN
C305
1 ORN
S303
1 ORN
LH FRONT DOOR LOCK SWITCH
LOCK
UNLOCK
RH FRONT DOOR LOCK SWITCH
1 BLK 194
1 LT BLU 195
8 BLK 194
8 LT BLU 195
S335
S336
DOOR LOCK RELAY
LOCK RELAY
UNLOCK RELAY
2 BLK 150
G312
1 TAN 294
2 TAN 294
S304
1 GRY 295
2 GRY 295
LH REAR DOOR LOCK MOTOR
LH FRONT DOOR LOCK MOTOR
RH FRONT DOOR LOCK MOTOR
RH REAR DOOR LOCK MOTOR
C307
C305
S305
C306

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REPORT ON MOTORIZED ACCESSORIES

REPORT ON NEW MOTORIZED FEATURES

Visit three auto dealerships and look at the latest-model cars. Discuss the new motorized accessories offered with sales representatives. Report your findings in writing or orally.

REPORT ON MOTORIZED ACCESSORIES REPAIR

Visit three auto service technicians. Discuss problems and customer complaints related to motorized accessories they find most often. Report your findings in writing or orally.

ASSIGNMENT SHEET 1

MOTORIZED ACCESSORIES

VII

NAME ______________________________ SCORE ________

OBJECTIVE 9 **Diagnose motorized tailgate problems.**

INTRODUCTION

Many tailgate windows can be activated by two switches: one at the dashboard and one at the tailgate. The circuit may be further complicated by other tailgate systems such as a rear window defogger or taillights.

Diagnosis, on the other hand, is not complicated. Easy visual testing can help pinpoint the location of the problem. If the window can be controlled by the switch at the tailgate but not by the dashboard switch, for example, the fault is obviously in the dashboard switch or the wiring between that switch and the tailgate.

DIRECTIONS

Locate a service manual for any General Motors tailgate window, 1987 or earlier. Using the information in that manual, list where the problem is in each of these situations.

1. The window will not operate when either the dashboard or tailgate switch is activated.

   ____

   ____

2. The window will operate if the tailgate switch is activated, but not if the dash switch is used.

   ____

   ____

3. The window will open, but will not close if the dash switch is used.

   ____

   ____

4. The window will operate from the dash switch, but not from the tailgate switch.

____

____

Service manual used ______________________________________

____

Page number ____________

ASSIGNMENT SHEET 2

MOTORIZED ACCESSORIES

VII

NAME ______________________________ SCORE ________

OBJECTIVE 10 **Diagnose power window circuit component problems.**

INTRODUCTION

It is usually easy to make a preliminary diagnosis of the cause of power window problems. Because there are two switches to operate passenger windows, you can determine which switch is affected quickly and easily. Even if a preliminary diagnosis is obvious, loads in the circuit should be tested to confirm the diagnosis. Three basic load tests are the master control switch test, the window control switch test, and the window motor test. Additional tests of connectors and other components are found in service manuals.

DIRECTIONS

Use a service manual to determine the correct answer. These questions were written using the service manual for a 1988 Celebrity, but answers should be correct for any car.

1. If the driver's master switch does not operate any window, but a test lamp lights when connected to wiring to the switch, what should be done?

   ____

   ____

2. Does your response to Question 1 depend upon whether the car has 2 or 4 doors?

   ____

3. If a test lamp connected to wiring leading to a window switch and to ground does not light, what is the probable fault?

   ____

   ____

NAME ________________________________ SCORE ________

OBJECTIVE 11

Diagnose power seat problems.

INTRODUCTION

Power seats can be affected by several things. If the battery is low, the seat is jammed, or something is blocking the path of the seat, performance will be compromised. If none of these problems exist, there are only three possible problems: one of the motors is faulty, the switch is faulty, or wiring is faulty. These components are located in the same area and testing is very simple.

DIRECTIONS

Read the paragraph below, then write an "1" before the first thing you would check, a "2" before the second, a "3" before the third, and a "4" before the fourth. Use a service manual to help you determine the most likely problem and appropriate service procedure.

> An AMC Alliance is brought to you for service to the power seat system. The driver's seat will not move, but the passenger's seat will. The owner mentions that the seat will move up and down just fine, but will not move back and forth.

______1. Battery charge

______2. Check under seat to see if it is jammed

______3. Check to see that the switch is getting voltage

______4. Test or replace front motor

______5. Test or replace rear motor

______6. Test or replace horizontal motor

______7. Test for faulty switch

ASSIGNMENT SHEET 4

MOTORIZED ACCESSORIES

VII

NAME ______________________ SCORE ________

OBJECTIVE 12 **Diagnose defogger circuit problems.**

INTRODUCTION Defogger circuits are tested using different procedures and standards, depending upon the make and model. Service manual instructions should always be followed.

DIRECTIONS Refer to Supplements 1-3 to answer the questions below. These refer to test procedures for a 1989 Prelude.

1. According to the troubleshooting chart, what is the most likely cause when a defogger doesn't operate even though the indicator telltale goes on?

   ____

2. During a switch input test, the voltage in a yellow/black wire is measured and is zero voltage. Does this indicate a faulty switch?

   ____

3. If a self-powered test lamp is connected to the circuit between the negative terminal and the body ground and it does not light, what is the probable cause?

   ____

4. A voltmeter is touched to the center of the positive connector at the defogger grid and 4V is read. Which direction is the fault?

   ____

ASSIGNMENT SHEET 5

MOTORIZED ACCESSORIES

VII

NAME ______________________________ SCORE ________

OBJECTIVE 13 **Diagnose power lock problems.**

INTRODUCTION When power door lock problems occur in a two-door, the locks may not operate from either door, they may work from only one door, or either door may open one door but not the other. Similar situations may occur in a four-door. Determining which of these is occurring will enable you to focus your testing on the most likely cause of the fault.

DIRECTIONS Use the wiring diagram in Supplement 5 to answer the following questions.

1. If the dome light does not come on when doors are open, could it be related to a power lock problem? Explain your answer.

   ____

2. If the PWR ACC circuit breaker is open, could it cause a power lock problem? Why or why not?

   ____

   ____

3. If the ground at G312 is loose, how will it affect the power locks?

   ____

   ____

4. What other system is connected in circuit?

   ____

ASSIGNMENT SHEET 6

MOTORIZED ACCESSORIES

VII

NAME ______________________________ SCORE ________

OBJECTIVE 14

Diagnose sunroof circuit problems.

INTRODUCTION

Sunroof repair often concerns alignment of or service to the window itself. Seals and proper fit are, of course, extremely important, and the electrical components of the sunroof must also be maintained and repaired. The first step in checking electrical problems should be to check the circuit for continuity at connectors. The switch, motor, and relay should also be tested. Because all these components are tested at terminals, it is important that you follow service manual procedures.

DIRECTIONS

Use the information is Supplement 4 to complete the sentences below.

1. During the function test, the white/yellow terminal should be connected to the black terminal with a ____________________ ______________.
2. If the connection in Question 1 is made and the ignition is ON, the sunroof should ______________.
3. The motor operation should be tested in each ____________________________.
4. During the relay test, when terminals E and F are connected to the battery, terminals A and C should have ______________________________.
5. There should be continuity between terminals B and C when the battery is ______________________________________.

NAME ______________________________ SCORE ________

OBJECTIVE 15

Diagnose electric mirror problems.

INTRODUCTION

Exterior mirrors can be affected by four possible problems: a blown fuse, a faulty switch, faulty wiring, damaged mirror assembly. Testing procedures are simple, but may require some dash or door part removal.

DIRECTIONS

Use the information given to complete the troubleshooting chart on page 59.

TROUBLE SHOOTING

ELECTRONIC REAR VIEW MIRROR

Mirror Does Not Operate

1. Check connectors for good contact. Check for a blown fuse. If fuse is okay, pull electrical connector from rear of mirror.

   NOTE: If back-up light switch is defective or back-up lights are on, mirror will not operate.

2. Turn ignition switch to "ON" position and place transmission selector in "PARK" position. Check for battery voltage between Red/Yellow and Black wire at feed harness.
3. If there is no voltage, check for voltage from Red/Yellow wire to a known good ground to determine which circuit is open.
4. If still no voltage or open ground is found, repair wiring. If wiring is okay, replace mirror assembly.

SIDE MIRRORS

Side Mirrors Do Not Operate

1. Check 15-amp fuse in fuse panel. If fuse is okay, remove door trim panel and check for power to switch by connecting test light across terminals No. 54 and 57. See Figures 1, 2, 3, 4, 5, and 6.
2. If no power is present, connect terminal No. 54 to ground and check for open in terminals No. 54 or 57. If open, trace circuit and correct problem. If power is present, connect jumper wire across terminals and check continuity. See Figures 1, 2, 3, 4, 5, and 6.
3. If mirrors can be operated while by-passing switch, replace switch.

One Side Mirror Does Not Operate

Check that wiring harness is connected to motor. Using test lamp, check for continuity of circuits in harness connector by operating switch. If there is no continuity, check that connectors in side cowl (Crown Victoria, Grand Marquis, Sable, Taurus and Town Car) or seat console (all other models) are properly engaged. If continuity is correct, replace damaged mirror.

Rear view mirror does not operate, check	Side mirrors do not operate, check	One side mirror does not work, check
1. ____________________	1. ____________________	1. ____________________
____________________	____________________	
2. ____________________	2. ____________________	
____________________	____________________	
3. ____________________	3. ____________________	
____________________	____________________	
4. ____________________		
____________________		

ASSIGNMENT SHEET 1

1. Faulty Power Accessory or Window circuit breakers
   Faulty ground
   Fault in wires leading to motor
   Defective motor

2. Defective dash switch
   Fault in dash switch wiring

3. Defective dash switch
   Fault in dash switch wiring
   Defective motor

4. Defective tailgate switch
   Fault in tailgate switch wiring

ASSIGNMENT SHEET 2

1. The Driver's Master Switch should be replaced.
2. No
3. An open circuit

ASSIGNMENT SHEET 3

2. 1
3. 2
7. 3
6. 4

ASSIGNMENT SHEET 4

1. Blown No. 23 (30 A) fuse.
2. No
3. An open in the ground wire.
4. Voltage drop between battery and connector.

ASSIGNMENT SHEET 5

1. Yes. Burned out Courtesy Fuse could cause both situations.
2. Yes. It would cause an open in the circuit.
3. It may cause intermittent problems or may appear as an open in the circuit.
4. Rear Wiper/Washer or courtesy lights.

ASSIGNMENT SHEET 6

1. jumper wire
2. open
3. direction
4. continuity
5. disconnected

ASSIGNMENT SHEET 7

Rear view mirror does not operate.	1.	Check connectors. Check for blown fuse. If fuse is good, pull electrical connector from back of mirror.
	2.	Turn ignition to ON and put car in PARK. Check battery voltage between Red/yellow and black wires at harness.
	3.	If no voltage is found, check for voltage from red/yellow to ground.
	4.	If open is found replace wiring. If no open is found, replace mirror assembly.
Side mirrors do not work.	1.	Check 15-amp fuse. If fuse is good, remove door panel and test power to switch by connecting a test lamp to terminals 54 and 57.
	2.	If no current, connect 54 and 57 to ground and test for continuity. Locate open and repair. If current is found, connect jumper wire across terminals.
	3.	If mirrors work with jumper wires bypassing terminals, replace switch.
One side mirror does not work	1.	Is wiring harness connected to motor? Test circuit continuity with test lamp. Check connectors. If still no continuity, replace mirror.

JOB SHEET 1

MOTORIZED ACCESSORIES

VII

OBJECTIVE 16a **Inspect and service motorized tailgate window system.**

TOOLS AND EQUIPMENT

- Service manual
- Jumper wires
- Test lamp
- Safety glasses
- Fender covers

PROCEDURE

1. Use the owner's or service manual to find proper tailgate operation.

2. Operate tailgate and compare the two.

3. Complete the following:

   - If the window will not respond to dashboard or tailgate switch:

     a. Test window circuit breaker.

     b. Test power accessory circuit breaker.

     c. Test for bad ground.

     d. Test for fault in wires to motor.

     e. Test for defective motor.

   - If the window will not respond to dashboard switch:

     a. Test window circuit breaker.

     b. Test dashboard switch.

     c. Test for fault in dashboard switch circuit wiring.

     d. Test lock-out switch.

- If dashboard switch works but tailgate switch does not:
    a. Test tailgate switch.
    b. Test for fault in tailgate switch circuit wiring.

4. Repair or replace as instructed in service manual.
5. Have your instructor check your work.
6. Put away tools and materials and clean the work area.

JOB SHEET 2

OBJECTIVE 16b **Inspect and service power window circuits.**

TOOLS AND EQUIPMENT

- Service manual
- Test lamp
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

NOTE: You are now in the car. Use floor mats and seat covers. Do not touch the dash or steering wheel with dirty hands. Do not adjust the radio or change stations. Do not open the glove box.

1. Activate each power window and master switch and observe their performance.
2. Consult service manual for proper performance description and compare to actual performance.
3. Check all circuit protection devices in the circuit. Repair or replace as necessary.
4. Complete the following:
   - **If none of the windows operate from any switch:**
     a. Test for voltage at circuit breakers.
     b. Test for power at master switch.
     c. Test for bad ground at master switch.
     d. Test for defective master switch.
   - **If a single window does not operate:**
     a. Test for a defective switch at that window.
     b. Test for a defective master switch.
     c. Test for an open circuit in that door.

        d. Test for defective motor at that window.

    - **If a single window responds to master switch, but not to window switch:**

        a. Test window switch.

        b. Test for open in wiring providing current to door.

5. Repair or replace according to service manual procedures.
6. Have your instructor check your work.
7. Put away tools and materials and clean the work area.

JOB SHEET 3

MOTORIZED ACCESSORIES

VII

OBJECTIVE 16c

Inspect and service power seat circuits.

TOOLS AND EQUIPMENT

- Service manual
- Diagnostic test equipment
- Jumper wires
- Test lamp
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Consult the service manual for proper power seat test procedures. If self-diagnostic or electronic readout tests are available, perform them following service manual procedures.

2. Before testing or servicing, check under seats. Are the seats jammed or blocked? If so, clear circuit area and operate seats.

3. Activate seats. Move them up, down, forward and back. Compare performance to description in service manual.

4. With dome light on, activate seats. If the dome light dims, check again for jam.

5. Test wiring to seats for continuity.

6. Test circuit breakers.

7. Check connectors.

8. Test motors.

   a. Follow test procedures in service manual. In some cases, failure in one motor may indicate a need to replace all three.

   b. Be sure to test each motor, then reverse leads and test again. If reversing the polarity causes motor to fail, then the motor should be replaced.

9. Repair or replace according to service manual instructions.

10. Have your instructor check your work.

OBJECTIVE 16c

Inspect and service power seat circuits.

TOOLS AND EQUIPMENT

- Service manual
- Diagnostic test equipment
- Jumper wires
- Test lamp
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Consult the service manual for proper power seat test procedures. If self-diagnostic or electronic readout tests are available, perform them following service manual procedures.

2. Before testing or servicing, check under seats. Are the seats jammed or blocked? If so, clear circuit area and operate seats.

3. Activate seats. Move them up, down, forward and back. Compare performance to description in service manual.

4. With dome light on, activate seats. If the dome light dims, check again for jam.

5. Test wiring to seats for continuity.

6. Test circuit breakers.

7. Check connectors.

8. Test motors.

   a. Follow test procedures in service manual. In some cases, failure in one motor may indicate a need to replace all three.

   b. Be sure to test each motor, then reverse leads and test again. If reversing the polarity causes motor to fail, then the motor should be replaced.

9. Repair or replace according to service manual instructions.

10. Have your instructor check your work.

11. Put away tools and materials and clean the work area.

JOB SHEET 4

MOTORIZED ACCESSORIES

VII

OBJECTIVE 16d

Inspect and service defogger circuit problems.

TOOLS AND EQUIPMENT

- Service manual
- Voltmeter
- Test lamp
- Jumper wires
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Consult a service manual and follow procedures outlined there.
2. Turn on the rear window defogger.
3. Observe performance and compare to service manual description.
4. Carry out self-diagnostic testing, if available.
5. Test control switch and timer relay.
    a. Verify that voltage registered in connectors is consistent with service manual specs.
    b. If low or no voltage is registered, test circuit for opens and check circuit protection devices.
6. Perform a grid test. Follow service manual procedures.
7. Repair or replace as necessary.
8. Have your instructor check your work.
9. Put away tools and materials and clean the work area.

JOB SHEET 5

MOTORIZED ACCESSORIES

VII

OBJECTIVE 16e

Inspect and service power lock circuits.

TOOLS AND EQUIPMENT

- Service manual
- Test lamp
- Jumper wires
- Multimeter
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Before testing, operate the power locks and observe their performance.
2. If the dome light does not come on when the doors are opened, check the courtesy fuse.
3. Check the door lock relay. Be sure it and the ground are making good contact. This is a very common problem.
4. Consult the service manual for recommended service procedures. Follow service manual instructions. If a self-diagnostic test is available, perform it.
5. Test the circuit protection devices.
6. Test the switch.
7. Test the motor. Be sure to test it, then reverse the leads, and repeat the test.
8. Repair or replace as instructed.
9. Have your instructor check your work.
10. Put away tools and materials and clean the work area.

JOB SHEET 6

MOTORIZED ACCESSORIES

OBJECTIVE 16f

Inspect and service sunroof circuit problems.

TOOLS AND EQUIPMENT

- Service manual
- Basic tools
- Test lamp
- Multimeter
- Jumper wires
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Sunroofs vary widely between makes and models. Refer to the appropriate service manual for testing and service procedures.
2. Observe the performance of the sunroof and compare it to service manual description.
3. Remove dash assembly or sunroof assembly, as required for testing.
4. Test connectors and circuit for continuity.
5. Test the switch. Be sure to test it, reverse the leads, and test it again.
6. Test the motor.
7. Test the relay.
8. Replace or repair as necessary.
9. Reassemble sunroof.
10. Have your instructor check your work.
11. Put away tools and materials and clean the work area.

OBJECTIVE 16g **Inspect and service electric mirror circuits.**

TOOLS AND EQUIPMENT

- Service manual
- Test lamp
- Basic tools
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Observe performance and compare to service manual description.
2. Locate service instructions in service manual.
3. Check circuit protection devices and repair/replace as necessary.
4. Remove door trim and test for voltage at the switch.
   a. If 0 voltage at the switch, trace circuit between switch and fuse block. Look for opens or grounds.
   b. If voltage to the switch is good, test past the switch. If voltage past the switch is good, replace the mirror assembly. If past the switch it is bad, replace the switch.
5. Replace door trim.
6. Have your instructor check your work.
7. Put away tools and materials and clean the work area.

PRACTICAL TEST 1

MOTORIZED ACCESSORIES

VII

JOB SHEET 1

Inspect and service motorized tailgate window system.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Used the owner's or service manual to find proper tailgate operation.	_____	_____
2. Operated tailgate and compared the two.	_____	_____
3. Completed the following:		
• **If the window did not respond to dashboard or tailgate switch:**		
a. Tested window circuit breaker.	_____	_____
b. Tested power accessory circuit breaker.	_____	_____
c. Tested for bad ground.	_____	_____
d. Tested for fault in wires to motor.	_____	_____
e. Tested for defective motor.	_____	_____
• **If the window did not respond to dashboard switch:**		
a. Tested window circuit breaker.	_____	_____
b. Tested dashboard switch.	_____	_____
c. Tested for fault in dashboard switch circuit wiring.	_____	_____
d. Tested lock out switch.	_____	_____

	YES	NO
• **If dashboard switch worked but tailgate switch did not:**		
a. Tested tailgate switch.	____	____
b. Tested for fault in tailgate switch circuit wiring.	____	____
4. Repaired or replaced as instructed in service manual.	____	____
5. Used proper tools correctly.	____	____
6. Performed steps in a timely manner.	____	____
7. Practiced safety rules throughout procedure.	____	____
8. Provided satisfactory responses to questions asked.	____	____
9. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Operated tailgate and compared performance to service manual description	4	3	2	1
Correctly evaluated symptoms	4	3	2	1
Performed all suggested tests	4	3	2	1
Followed service manual procedures completely	4	3	2	1
Performed all necessary service procedures	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 2

MOTORIZED ACCESSORIES

VII

JOB SHEET 2

Inspect and service power window circuits.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Activated each power window and master switch and observed its performance.	_____	_____
2. Consulted service manual for proper performance description and compared to actual performance.	_____	_____
3. Checked all circuit protection devices in the circuit. Repaired or replaced as necessary.	_____	_____
4. Completed the following:		
• **If none of the windows operated from any switch:**		
a. Tested for voltage at circuit breakers.	_____	_____
b. Tested for power at master switch.	_____	_____
c. Tested for bad ground at master switch.	_____	_____
d. Tested for defective master switch.	_____	_____

	YES	NO
• **If a single window did not operate:**		
a. Tested for a defective switch at that window.		
b. Tested for a defective master switch.		
c. Tested for an open circuit in that door.		
d. Tested for defective motor at that window.		
• **If a single window responded to master switch, but not to window switch:**		
a. Tested window switch.		
b. Tested for open in wiring providing current to door.		
5. Repaired or replaced according to service manual procedures.		
6. Used proper tools correctly.		
7. Performed steps in a timely manner.		
8. Practiced safety rules throughout procedure.		
9. Provided satisfactory responses to questions asked.		
10. Put away tools and cleaned work area.		

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Activated and observed each window and compared to service manual description	4	3	2	1
Located and checked all circuit protection devices	4	3	2	1
Completed all test procedures as instructed in service manual	4	3	2	1
Completed all repair or replacement according to service manual instructions	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program, additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3

MOTORIZED ACCESSORIES

VII

JOB SHEET 3

Inspect and service power seat circuits.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. a. Consulted the service manual for proper power seat test procedures.	_____	_____
b. If self-diagnostic or electronic readout tests were available, performed them following service manual procedures.	_____	_____
2. Before testing or servicing, checked under seats for jams.	_____	_____
3. a. Activated seats. Moved them up, down, forward and back.	_____	_____
b. Compared performance to description in service manual.	_____	_____
4. With dome light on, activated seats. If the dome light dimmed, checked again for jam.	_____	_____
5. Tested wiring to seats for continuity.	_____	_____
6. Tested circuit breakers.	_____	_____
7. Checked connectors.	_____	_____

	YES	NO
8. Tested motors.		
a. Followed test procedures in service manual	____	____
b. Tested each motor, then reserved leads and tested again.	____	____
9. Repaired or replaced according to service manual instructions.	____	____
10. Used proper tools correctly.	____	____
11. Performed steps in a timely manner.	____	____
12. Practiced safety rules throughout procedure.	____	____
13. Provided satisfactory responses to questions asked.	____	____
14. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
	4	3	2	1
Consulted the service manual and carefully followed all instructions				
	4	3	2	1
Before testing or servicing, checked for jams and activated seats, watching their performance				
	4	3	2	1
Tested wiring to seats, circuit breakers, and connectors				
	4	3	2	1
Tested motors carefully, following manual instructions				
	4	3	2	1
Repaired or replaced according to service manual instructions				

EVALUATOR'S COMMENTS

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 4

MOTORIZED ACCESSORIES

VII

JOB SHEET 4

Inspect and service defogger circuit problems.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Consulted a service manual and followed procedures outlined there.	_____	_____
2. Turned on the rear window defogger and compared performance to service manual description.	_____	_____
3. Carried out self-diagnostic testing, if available.	_____	_____
4. Tested control switch and timer relay.	_____	_____
5. Performed a grid test.	_____	_____
6. Repaired or replaced as necessary.	_____	_____
7. Used proper tools correctly.	_____	_____
8. Performed steps in a timely manner.	_____	_____
9. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
10. Provided satisfactory responses to questions asked.	____	____
11. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Consulted a service manual and followed all procedures	4	3	2	1
Tested control switch, timer, and relay	4	3	2	1
Verified that voltage registered at recommended level	4	3	2	1
Performed a grid test	4	3	2	1
Repaired or replaced as necessary	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 5

MOTORIZED ACCESSORIES

JOB SHEET 5

Inspect and service power lock circuits.

STUDENT'S NAME ________________ DATE ____________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Before testing, operated the power locks and observed their performance.	_____	_____
2. If the dome light did not come on when the doors were opened, checked the courtesy fuse.	_____	_____
3. Checked the door lock relay.	_____	_____
4. Consulted the service manual for recommended service procedures. Followed service manual instructions. If a self diagnostic test was available, performed it.	_____	_____
5. Tested the circuit protection devices.	_____	_____
6. Tested the switch.	_____	_____
7. Tested the motor.	_____	_____
8. Repaired or replaced as necessary.	_____	_____
9. Used proper tools correctly.	_____	_____

	YES	NO
10. Performed steps in a timely manner.	____	____
11. Practiced safety rules throughout procedure.	____	____
12. Provided satisfactory responses to questions asked.	____	____
13. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Before testing, operated the power locks and observed their performance carefully	4	3	2	1
Checked the door lock relay and ground carefully	4	3	2	1
Consulted the service manual and followed recommended service procedures carefully	4	3	2	1
Tested the switch and motor carefully	4	3	2	1
Repaired or replaced as necessary	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Inspect and service sunroof circuit problems.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Referred to the appropriate service manual for testing and service procedures.	_____	_____
2. Observed the performance of the sunroof and compared it to service manual description.	_____	_____
3. Removed dash assembly or sunroof assembly, as required for testing.	_____	_____
4. Tested connectors and circuit for continuity.	_____	_____
5. Tested the switch.	_____	_____
6. Tested the motor.	_____	_____
7. Tested the relay.	_____	_____
8. Replaced or repaired as necessary.	_____	_____
9. Reassembled sunroof.	_____	_____

	YES	NO
10. Used proper tools correctly.		
11. Performed steps in a timely manner.		
12. Practiced safety rules throughout procedure.		
13. Provided satisfactory responses to questions asked.		
14. Put away tools and cleaned work area.		

EVALUATOR'S COMMENTS ______________________________

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Referred to the appropriate service manual and followed procedures carefully	4	3	2	1
Removed dash assembly or sunroof assembly	4	3	2	1
Tested connectors and circuit for continuity carefully	4	3	2	1
Tested the switch, motor and relay	4	3	2	1
Repaired or replaced as necessary and reassembled dash correctly	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 7

MOTORIZED ACCESSORIES

VII

JOB SHEET 7

Inspect and service electric mirror circuits.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Observed performance and compared to service manual description.	_____	_____
2. Located service instructions in service manual.	_____	_____
3. Checked circuit protection devices and repaired/replaced as necessary.	_____	_____
4. Removed door trim and tested for voltage at the switch.		
a. If voltage at the switch, traced circuit between switch and fuse box.	_____	_____
b. If voltage to the switch was good, tested past the switch. If voltage past the switch was good, replaced the mirror assembly. If past the switch it was bad, replaced the switch.	_____	_____
5. Replaced door trim.	_____	_____
6. Used proper tools correctly.	_____	_____

	YES	NO
7. Performed steps in a timely manner.		
8. Practiced safety rules throughout procedure.		
9. Provided satisfactory responses to questions asked.		
10. Put away tools and cleaned work area.		

EVALUATOR'S COMMENTS

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Observed performance carefully and used proper service manual	4	3	2	1
Tested protection devices carefully	4	3	2	1
Removed door trim and tested continuity before and after the switch	4	3	2	1
Repaired or replaced as indicated	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

MOTORIZED ACCESSORIES

VII

NAME ______________________________ SCORE ________

OBJECTIVE 1 **State general principles of motorized accessories.**

____

____

____

____

____

____

OBJECTIVE 2 **Complete statements about the tailgate window circuit.**

1. Rear window circuits include the battery and

   ____________________ switch wiring.

2. Two other electrical components that may be found in the tailgate compartment are

   ____

   ____

3. Rear window circuits operate like any power window. When

   current flows through the circuit, one terminal is a

   _______________ and the other _____________

   __________________ to the motor.

4. Depending on the polarity, the window is

   _______________ or__________________.

OBJECTIVE 3

Select from a list true statements about power window circuits.
Write an "X" in the blank before true statements.

_______1. The power window circuit includes a driver's switch, a driver's motor, a passenger's switch, a passenger's motor and a power window relay.

_______2. When the ignition is in ON, current is supplied to the switches.

_______3. When the switch is released, the connection is broken and the motor stops.

_______4. When a switch is pushed to the UP position, the circuit is completed and the window motor runs.

_______5. Current is supplied to the circuit at all times.

_______6. When a switch is pushed to the UP position, the circuit is completed and the window gears are engaged.

_______7. When the switch is released, the connection is broken and the motor runs.

_______8. When a switch is pushed to the UP position, the circuit is open and sensors are activated.

_______9. When the switch is pushed to the DOWN position, the second wire between the switch and motor becomes the pathway for the current and polarity is reversed.

______10. When the driver's master switch is activated, current runs to all motors.

OBJECTIVE 4

Discuss power seat circuits.

1. What motors are used in power seat circuits?

____

____

____

2. How is the height of the seat controlled?

____

____

____

____

____

3. How is the seat moved forward and back?

____

____

____

____

____

OBJECTIVE 5

Arrange in order rear window defogger circuit procedure. Write a "1" in the blank before the first step, a "2" in the blank before the second step, etc.

______a. Voltage is applied to the rear window defogger switch.

______b. Current flows to a rear window defogger timer unit.

______c. The timer shuts off voltage after a time limit is reached.

______d. The defogger and the defogger indicator telltale are activated.

______e. The ignition is in ON.

OBJECTIVE 6

Distinguish among power lock circuit functions. Write an "O" in the blank before statements describing using the power lock system from outside the car; an "I" before statements describing using the system from inside the car. More than one answer may be correct.

______1. All doors may lock when any one door is locked.

______2. All doors can be locked or unlocked from the driver's door.

______3. In some cases, all doors will unlock when any door is unlocked.

______4. A lock-out feature prevents passenger locks from working, unless activated at the driver master switch.

OBJECTIVE 7 **Complete statements about electric sunroof circuits.**

1. Components in the electric sunroof circuit include a

_________________, a _________________, and a

_________________.

2. Sunroofs are controlled by a ___________________________

motor located in the roof of the car.

3. A cam and ________________ __________________ pull the

sunroof open or shut.

4. Sunroofs can also be operated manually with a

_______________.

OBJECTIVE 8 **Distinguish between interior and exterior electric mirror circuits.** Write an "E" in the blank before exterior mirror circuits. Write an "I" in the blank before interior mirror circuits.

______1. In some cars, a rear-view mirror adjusts automatically to reduce nighttime glare.

______2. Two motors are used to control the tilt. One controls the horizontal tilt, and one the vertical.

______3. A switch in the dashboard or console allows the driver to designate which mirror is to be adjusted and to make the adjustments.

______4. Two sensors measure light hitting the front and back of the mirror and adjustments are made to equalize the two.

NOTICE	The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.	
OBJECTIVE 9	**Diagnose motorized tailgate problems.**	SCORE ______
OBJECTIVE 10	**Diagnose power window circuit component problems.**	SCORE ______
OBJECTIVE 11	**Diagnose power seat problems.**	SCORE ______
OBJECTIVE 12	**Diagnose defogger circuit problems.**	SCORE ______
OBJECTIVE 13	**Diagnose power lock problems.**	SCORE ______
OBJECTIVE 14	**Diagnose sunroof circuit problems.**	SCORE ______
OBJECTIVE 15	**Diagnose electric mirror problems.**	SCORE ______
OBJECTIVE 16a	**Inspect and service motorized tailgate window system.**	RATING ______
OBJECTIVE 16b	**Inspect and service power window circuits.**	RATING ______
OBJECTIVE 16c	**Inspect and service power seat circuits.**	RATING ______
OBJECTIVE 16d	**Inspect and service defogger circuit problems.**	RATING ______
OBJECTIVE 16e	**Inspect and service power lock circuits.**	RATING ______
OBJECTIVE 16f	**Inspect and service sunroof circuit problems.**	RATING ______
OBJECTIVE 16g	**Inspect and service electric mirror circuits.**	RATING ______

OBJECTIVE 1

Discussion should include:

- Motorized accessories are not necessary for operation of the car.
- They use a motor usually (but not always) to move something
- They are electrical but may include electronic circuitry.

OBJECTIVE 2

1. ignition
2. any two of:
    - rear window defogger
    - radio speakers
    - other radio components
    - rear brake lights
    - signal light
    - motorized latch
    - heater/air conditioner circuitry
3. ground
   feeds current
4. raised
   lowered

OBJECTIVE 3

1, 2, 3, 4, 9

OBJECTIVE 4

1. Front Height Motor
   Rear Height Motor
   Forward Back Motor
2. Answer should include:
    - Controlled by two different motors
    - Entire seat moves when both motors are activated
    - Direction is changed when polarity is changed.
3. Answer should include:
    - Controlled by Forward Back Motor
    - Reversing polarity changed direction

OBJECTIVE 5

a. 2
b. 3
c. 5
d. 4
e. 1

OBJECTIVE 6

1. O or I 3. O
2. I or O 4. I

OBJECTIVE 7

1. switch, motor, and relay
2. reversible
3. drive cables
4. hand crank

OBJECTIVE 8

1. I
2. E
3. E
4. I

OBJECTIVE 9

Refer to Answers to Assignment Sheet 1.

OBJECTIVE 10

Refer to Answers to Assignment Sheet 2.

OBJECTIVE 11

Refer to Answers to Assignment Sheet 3.

OBJECTIVE 12

Refer to Answers to Assignment Sheet 4.

OBJECTIVE 13

Refer to Answers to Assignment Sheet 5.

OBJECTIVE 14

Refer to Answers to Assignment Sheet 6.

OBJECTIVE 15

Refer to Answers to Assignment Sheet 7.

OBJECTIVE 16

Refer to Practical Tests for Job Sheets 1-7.

OBJECTIVE SHEET

DRIVER INFORMATION SYSTEMS *VIII*

INTRODUCTION

Driver information systems are changing rapidly. Early systems were mechanical and provided the driver with approximations of basic information, such as speed and fuel level. Later, many systems used analog equipment for more exact measurement. Today, electronic systems include a myriad of driver information: speed, miles per gallon, time to destination, engine status, and even maps of major highways! This variety of system types and components requires a solid knowledge of basic system types and component operation combined with consistent use of the manufacturer's service manual.

UNIT OBJECTIVE

After completing this unit, the student should know and be able to inspect and service the types, components, operation, and service of clusters, gauges, warning lights, audible alarms, indicators, and voice notification systems. The student will demonstrate these competencies by completing assignments sheets, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with servicing driver information systems to their correct definitions.
2. List common components.
3. Distinguish among system designs.
4. Select from a list true statements about the operation of gauges.
5. Complete statements about the operation of electronic indicators.
6. Select from a list true statements about audible alarms.
7. Answer questions about voice notification systems.
8. Diagnose warning light systems. (Assignment Sheet 1)
9. Complete a gauge system troubleshooting chart. (Assignment Sheet 2)

10. Diagnose electronic indicator problems. (Assignment Sheet 3)

11. Diagnose audible alarm problems. (Assignment Sheet 4)

12. Diagnose voice notification system problems. (Assignment Sheet 5)

13. Demonstrate the ability to:

    a. Inspect and service warning lights. (Job Sheet 1)

    b. Inspect and service gauges. (Job Sheet 2)

    c. Test electronic indicators. (Job Sheet 3)

    d. Inspect and service audible alarms. (Job Sheet 4)

    e. Inspect and service voice notification system problems. (Job Sheet 5)

    f. Replace PROM. (Job Sheet 6)

SUGGESTED ACTIVITIES

DRIVER INFORMATION SYSTEMS

VIII

PREPARATION

- Review unit and plan presentation.
- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.
- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.
- Review teaching suggestions and plan classroom activities.
- Determine how you will schedule time for students to demonstrate competence in the required procedures.
- Order materials to supplement unit.
- Invite an electronics engineer or automotive designer to speak to the class about sensors and indicators.
- Invite a service specialist to speak to the class about common repair procedures and problems.

NOTE: Supply guest speakers with the Objective Sheet, Information Sheet and any other components you want them to cover.

DELIVERY

Objective 1 Match terms associated with servicing driver information systems to their correct definitions.
Objective 2 List common components.
Objective 3 Distinguish among system designs.

- It may be necessary to add more terms and definitions to the list given here. Terms and functions covered in Unit 2 (electronics) may need to be reviewed.
- Have students list all the components they can think of or find in service manuals to make them aware of the wide range of driver information system components.

- The list here focuses on the units found in the cluster rather than parts within each unit or the variety of sensors and switches.

- Show students examples of sensors. A variety of sensors and charts showing sensor locations should be displayed.

- Some references may consider other types of systems: analog vs. digital, mechanical vs. electronic, etc.

- Have students complete Assignment Sheet 1 and Job Sheet 1 to support Objective 3.

Objective 4 Select from a list true statements about the operation of gauges.
Objective 5 Complete statements about the operation of electronic indicators.
Objective 6 Select from a list true statements about audible alarms.
Objective 7 Answer questions about voice notification systems.

- Have students complete Assignment Sheets and Job Sheets to support objectives as shown in the Information Sheet.

- The operations of these instruments are all very similar. Students should become familiar with the voltages on the various circuits and the circuit operations, rather than studying the individual modules in depth.

- Some instruments, such as gauges, may be familiar to students without them understanding how the instruments operate. Other instruments, such as the voice notification systems, may be less familiar to students, even though they understand how it functions.

- Show videotape *Oscilloscope Operation and Measurement.*

- Allow students to recognize these instruments in other settings. Have students list gauges, warning lights, indicators, audible alarms, and voice notification systems they find outside automobiles. Be sure they include computers, stereo systems, microwave ovens, and other everyday items.

APPLICATION

Objective 8 **Diagnose warning light systems.** (Assignment Sheet 1)

Objective 9 **Complete a gauge system troubleshooting chart.** (Assignment Sheet 2)

Objective 10 **Diagnose electronic indicator problems.** (Assignment Sheet 3)

Objective 11 **Diagnose audible alarm problems.** (Assignment Sheet 4)

Objective 12 **Diagnose voice notification system problems.** (Assignment Sheet 5)

Objective 13 **Demonstrate the ability to:**

a. **Inspect and service warning lights.** (Job Sheet 1)

b. **Inspect and service gauges.** (Job Sheet 2)

c. **Test electronic indicators.** (Job Sheet 3)

d. **Inspect and service audible alarms.** (Job Sheet 4)

e. **Inspect and service voice notification system problem.** (Job Sheet 5)

f. **Replace PROM.** (Job Sheet 6)

- As students complete Assignment and Job Sheets, stress the wide range of system test procedures. Explain to students that service manual procedures must be followed.

- Have students compare service procedures for fuel gauges, oil pressure gauges, self-diagnosis tests, and other units between several makes.

- As students follow service manual procedures, ask them to explain what they are testing. If they can only give "brown wire" or similar answers, have them trace the wire and determine why the test they are performing is necessary.

EVALUATION

Pretest

- Pretest qualifying students.

- Determine individual requirements from pretest results.
- Counsel students individually on pretest results and study requirements.
- Modify materials in unit or create supplementary materials for individual students as required.

Practical test.

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test.

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.
- Complete appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Media

- *The Basics of Automobile Computer Control Sensors*. Five-part VHS series, 60 min., or filmstrips and teacher's guide. Includes how the oxygen sensor works, how the MAP and BARO sensors work, how the coolant temperature sensor works, how the throttle position sensor works, and how the knock sensor works. Order No. 30897-127, available from Vocational Media Association, 1-800-431-1242.

- *Oscilloscope Operation and Measurement.* This videotape is part of General Motors Course Materials collection. Order it by writing General Motors Training Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28635 Mound Road, Warren, MI 48092 or call 1-800-468-6657. Order number GM-18001-2V1.

Publications

- General Motors offers three electronic instrumentation books: *Electronic Instrumentation—Buick (GM-19010-001); Electronic Instrumentation—Chevrolet (GM-19010-021); Electronic Instrumentation—Pontiac (GM-19010-041).* These publications cover fundamentals and operations of clusters, operations, diagnosis, and service of displays, and driver information system fundamentals. To order, contact General Motors Training Material Merchandising, Kent-Moore Tool and Equipment Division, SPX Corporation, 28635 Mound Road, Warren, MI 48029 or call 1-800-468-6657.

Unit References

- *1988 Celebrity Electrical Diagnosis Service Manual Supplement.* General Motors, 1988.
- *Electronics Student Reference Book.* Chrysler Corp., nd.
- *C/K Pickup Electrical Diagnosis and Wiring Diagrams.* General Motors, 1989.
- *Electronic Instrumentation — Buick.* General Motors, 1985.
- Mackert, Howard C. and Russell L. Heiserman. *Automotive Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1988.
- *Mitchell Electrical Service and Repair Domestic Cars, 1987 Supplement.* San Diego, California: Mitchell International, Inc., 1987.

PRETEST ANSWERS

DRIVER INFORMATION SYSTEMS

VIII

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and written pretest questions.

Objective	Questions
1	1-5
2	6-7
3	8-10
4	11
5	12
6	13-14
7	15-17
8	18-21
9	22-24
10	25
11	26
12	27
13	28-32

ANSWER KEY

1. a
2. b
3. b
4. a
5. c
6. a
7. b
8. c
9. a
10. b
11. c
12. a
13. c
14. b
15. e
16. b
17. a
18. a
19. b
20. a
21. a
22. c
23. b
24. a
25. c
26. a
27. b
28. b
29. a
30. c
31. a
32. b

DRIVER INFORMATION SYSTEMS

NAME ______________________ SCORE ________

______1. "Analog" means signals whose voltage ___.

a. varies
b. values are either one of only two options
c. is in the form of sine waves

______2. "Digital" means signals whose voltage ___.

a. values can be anywhere between an upper and lower limit
b. values are either one of only two options
c. is in the form of sine waves

______3. Units made of special liquid between two panes of glass and a halogen light that illuminates when current is applied to the glass are ___.

a. LEDs
b. LCDs
c. VTFs

______4. Electronic parts that produce light when charged with electric current are ___.

a. LEDs
b. LCDs
c. VTFs

______5. Units using a cathode, anode, screen, and electrons to produce a picture are ___.

a. LEDs
b. LCDs
c. VTFs

______6. Driver information system components include the ___.

a. speedometer, fuel gauge, indicator telltales, sensors, and logic unit
b. battery, wiring, odometer, and courtesy lights
c. a and b

______7. Examples of indicator telltales are ___.

a. brake warning light, fasten seat belt telltale, and fasten seat belt chimes
b. key left in ignition chime, fasten seat belt chime, and headlights left on chime
c. brake warning light, fasten seat belt telltale, and high beam indicator

______8. Driver information systems that provide estimates of measurements for older model cars are ___.

a. quartz-electric
b. digital
c. mechanical

______9. Electronic driver information systems that use dials and swing needles are ___.

a. quartz-electric
b. digital
c. mechanical

_____10. Electronic driver information systems controlled by monitors that measure voltage changes in a buffer are ___.

a. quartz-electric
b. digital
c. mechanical

_____11. Gauge needles are moved by ___.

- a. gears
- b. electronic switches
- c. magnetic fields

_____12. Electronic indicators light when ___.

- a. the circuit is grounded
- b. circuit breakers open
- c. the headlight switch is operated

_____13. Audible alarms are ___.

- a. electronic components connected to warning light modules
- b. part of the horn assembly
- c. housed in a single audible alarm module

_____14. Audible alarms are typically sounded when ___.

- a. a circuit is grounded
- b. two or more circuits are completed
- c. a switch is activated

_____15. Sensors used in voice notification systems include all EXCEPT sensors that ___.

- a. indicate a failure
- b. are temperature-sensitive resistors
- c. monitor charging system voltage
- d. monitor temperature, light, or speed
- e. increase engine temperature

_____16. When voice notifications systems are activated, voltage is sent to the audible alarm module and the ___.

- a. courtesy lights flash briefly
- b. radio is interrupted
- c. VNS indicator is lit

_____17. Voice notification system modules are ___.

a. easily repaired with basic tools and a multimeter
b. virtually unbreakable
c. usually unrepairable and must be replaced

_____18. Driver information systems ___.

a. vary greatly among makes and models
b. are all pretty similar
c. are not found in all vehicles

_____19. The first steps in testing a driver information system are ___.

a. testing circuit voltage with a multimeter and checking the battery visually
b. observing the performance of the cluster and activating self-diagnostic tests
c. connecting the automobile's CPU to diagnostic equipment

_____20. If a single component in a cluster fails to operate properly, the cluster should be ___.

a. tested with internal self-diagnostic procedures anyway
b. ruled out as a problem
c. replaced

_____21. If all warning lights fail to illuminate, proper service is to replace the ___.

a. cluster
b. bulb
c. connector

_____22. If a fuel gauge reads empty all the time, what is indicated?

a. A short into the speedometer cable.
b. A faulty gauge.
c. An open between the cluster and the fuel tank.

_____23. If a fuel gauge reads full all the time, what is indicated?

a. A faulty E coil in the gauge.
b. A ground between the cluster and the sending unit.
c. A shorted or cracked connector.

_____24. If the fuel tank is damaged, the fuel gauge may also be affected.

a. True
b. False

_____25. Electronic indicators reflect the readings of ___.

a. alternator current
b. circuit resistance
c. sensors throughout the car

_____26. Audible alarms work within the circuit in much the same manner as ___.

a. lights or other switch-operated units
b. a diode or other resistor
c. a circuit breaker

_____27. Testing voice notification systems ___.

a. is very different from testing other systems
b. uses the same basic steps taken to test other systems
c. is performed only at specialized factory repair centers

_____28. If a warning light comes on briefly when the car is started then goes out, it is probably ___.

- a. shorted or burned out
- b. functioning properly
- c. indicating a faulty connection

_____29. If a gauge circuit is tested for continuity from the battery to gauge and continuity is low, ___.

- a. check the circuit for opens or loose connections and the printed circuits for flaws
- b. the gauge is working correctly
- c. the battery needs to be checked for electrolyte balance

_____30. When a customer complains that indicator lights are not working properly, the first thing to do is ___.

- a. check all bulbs and connectors
- b. run a self-diagnostic test
- c. determine if a problem really exists or if the owner doesn't understand the indicators

_____31. When observing the performance of audible alarms, the technician should also observe ___.

- a. courtesy and warning lights
- b. horn performance
- c. telltales

_____32. Voice notification system monitors should be replaced when it ___.

- a. talks when it's not supposed to
- b. talks when disconnected from monitor
- c. gives chime tone but does not give a message

OBJECTIVE 1 **Match terms associated with servicing driver information systems to their correct definitions.**

- **Analog** — Signals whose voltage varies

  EXAMPLE: A needle-type fuel gauge that can register anywhere between full and empty.

- **Buffer** — A solid-state device for processing electronic signals generated by sensors
- **Cluster** — A group of electrical and electronic instruments grouped together for the common function of driver information
- **Digital** — Signals whose voltage values are either one of only two options

  EXAMPLES: On or off; high or low

- **LCD's (Liquid crystal displays)** — A unit made of a halogen light and a special liquid between two panes of glass. When current is applied to the glass, the liquid allows light to pass through it; when current is removed, it remains opaque.
- **LED's (Light emitting diodes)** — Electronic parts that produce light when charged with electric current
- **VTF (Vacuum tube florescent displays)** — A unit using a cathode, anode, screen and electrons to produce a picture

OBJECTIVE 2 **List common components.**

- Speedometer
- Tachometer
- Fuel Gauge
- Odometer/Trip Odometer
- Audible Alarm Module
- Voice Notification Module and Monitoring Unit

- Indicator Telltales

  EXAMPLES: Seat belt, door ajar, high beams on, or upshift indicator telltales.

- Warning lights and indicators

  EXAMPLES: Oil or temperature warning lights

- Sensors, amplifiers, and buffers
- ECM

OBJECTIVE 3 **Distinguish among system designs.**

- **Mechanical**
  - Activated devices with mechanical transducers, cables, and sensors
  - Limited to older models
  - Provides estimates of measurements.
- **Quartz-electric swing needle**
  - Used for speedometers, odometers, and trip odometers
  - Uses dials and swing needles, so appearance and service are similar to mechanical
  - Uses a precision quartz crystal oscillator and electronics to improve accuracy
  - A sensor sends information to a buffer that processes it into information the system can use. Integrated circuits in the automobile's ECM (logic center) use input to determine the direction and amount of magnetic force in the gauge coils.
  - Provides estimates of measurements
- **Digital**
  - More accurate and attractive

  - May read out in numbers or bar graphs
  - May use LED's (light emitting diodes), LCD's (liquid crystal displays) or VTF (vacuum tube fluorescent) displays
  - Uses electronic data, but may also use mechanical input, such as a speedometer cable
  - A sensor sends information to a buffer that processes it into a format the system can use. The system sends voltage to the buffer. The buffer adjusts the voltage according to the sensor input. The system monitors the voltage and the logic unit uses it to calculate output.

OBJECTIVE 4 **Select from a list true statements about the operation of gauges.**

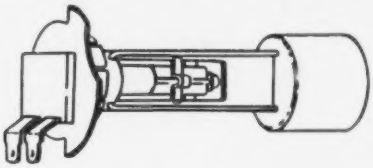
- Each gauge is made of a pointer and two wire coils at right angles to each other.
- Current is introduced into the coils and a magnetic field is generated around each one.
- The needle is attracted to one or both coils to position it for driver information.
- The automobile's logic unit monitors the amount of current each coil receives. By controlling the current or resistance in each coil, the strength of the magnetic fields is adjusted.

OBJECTIVE 5 **Complete statements about the operation of electronic indicators.**

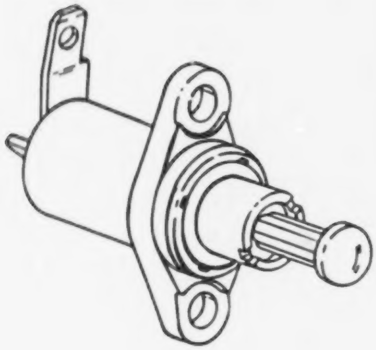
- Electronic indicators are always supplied with current. They light when the circuit is grounded.
- Electronic indicators are connected to sensors or switches which react to the status of the part or system being monitored. Sensors can react to pressure or voltage. Switches can react to temperature or resistance.
- Sensors and switches come in a variety of types and functions.

MESSAGE CENTER SWITCHES/SENSORS

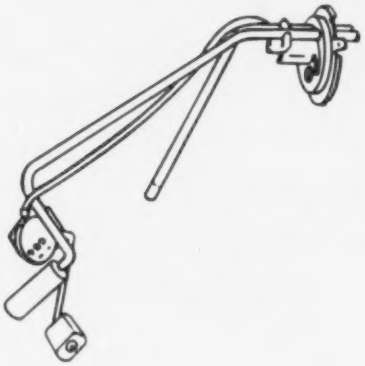
Windshield washer low fluid sensor



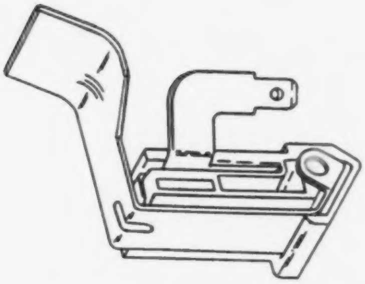
Door ajar switches



Low fuel switch



Lift gate ajar (hatch)



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- Indicators can be lit by LED's, LCD's, or VTF's.

OBJECTIVE 6 **Select from a list true statements about audible alarms.**

- Audible alarms can be used to warn, inform, or remind drivers. Their most common uses are to remind drivers to buckle their seat belts, remove their keys from the ignition, and turn off their lights.

- A central audible alarm module sounds a tone when a predetermined set of messages is received from sensors and switches.

- The typical audible alarm sounds when two or more circuits are completed (i.e., courtesy light circuit is closed when door is opened and ignition key warning switch circuit is closed when key is inserted). An alarm circuit is then grounded and the alarm sounds.

OBJECTIVE 7 **Answer questions about voice notification systems.**

- **Voice notification systems use five types of sensors.**

  — Sensors that detect a failure and send voltage to the logic unit when failure occurs (used to check lights).

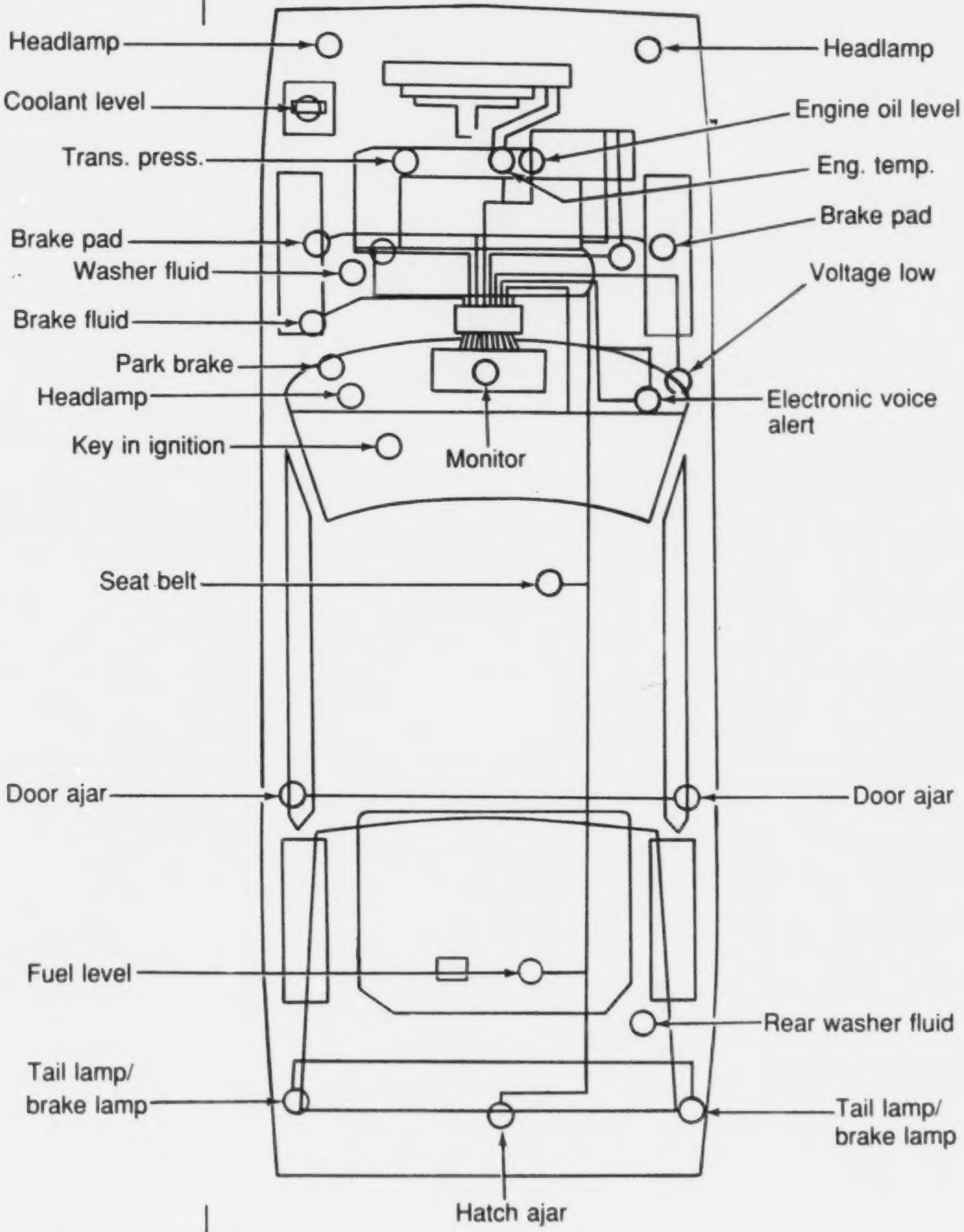
  — Temperature-sensitive resistors that notify the logic unit when resistance is high or low.

  — Sensors that monitor charging-system voltage.

  — Sensors that are open switches. When closed, they complete a circuit to the microcomputer indicating failure or danger. They are used to activate door-ajar warnings, check oil pressure, and brake-pad wear.

  — Specialized sensors that monitor temperature, light, or speed used in the coolant system, speedometer, and ignition system.

24 FUNCTION ELECTRONIC MONITOR WITH VOICE ALERT COMPONENTS


Headlamp
Headlamp
Coolant level
Engine oil level
Trans. press.
Eng. temp.
Brake pad
Brake pad
Washer fluid
Voltage low
Brake fluid
Park brake
Headlamp
Electronic voice alert
Key in ignition
Monitor
Seat belt
Door ajar
Door ajar
Fuel level
Rear washer fluid
Tail lamp/ brake lamp
Tail lamp/ brake lamp
Hatch ajar

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- When sensors send predetermined information to the automobile's logic center, voltage is sent to the audible alarm module and an alarm is sounded. At the same time, the radio may be interrupted. Finally, the voice notification is sounded.

- The voice notification may be a series of pre-recorded messages or a series of pre-recorded vocal sounds that may be put together by the logic unit to simulate speech.

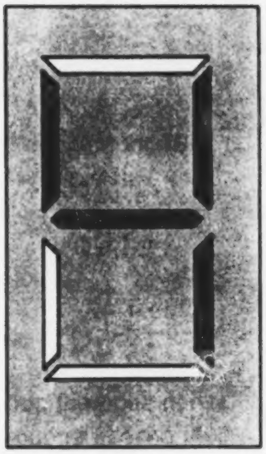
  NOTE: Voice notification units are available in many languages and with either male or female voices.

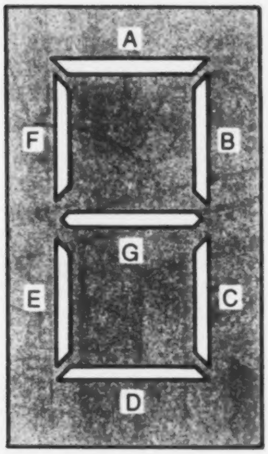
- Voice notification systems may be adjusted and muted, but if a fault exists within the unit itself, the system should be replaced rather than repaired.

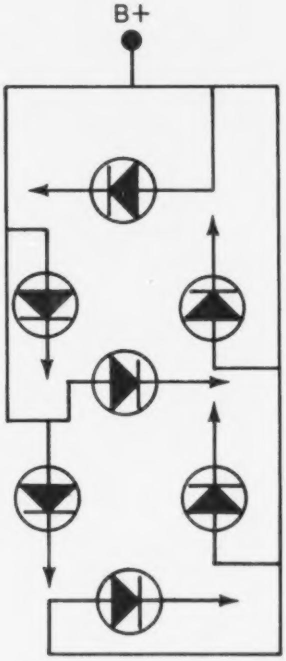
TYPES OF ELECTRONIC INDICATORS

Light Emitting Diode (LED)

An LED is a semiconductor device made in such a way that when current flows through it, light is emitted. LED's are usually red, yellow, or green but can be any color. LED's can be small lights in a dot matrix or bar graph units, but are most commonly used in a seven-segment display used to represent letters or numbers.







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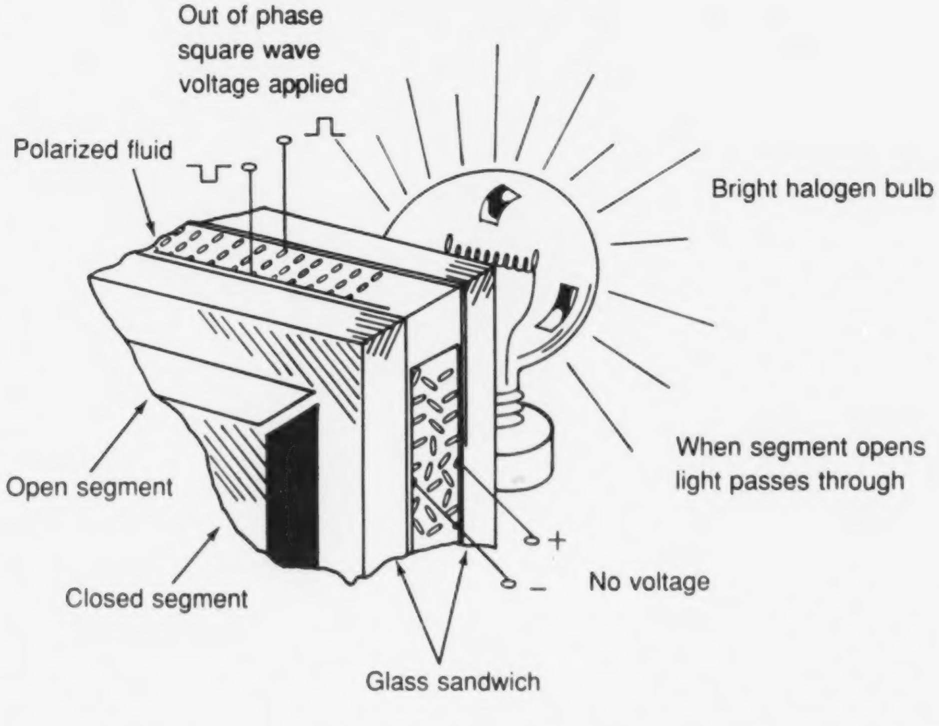
Disadvantages of LED's are that they are sometimes difficult to see in sunlight and that they require more power than other electronic displays.

Liquid Crystal Display (LCD)

The LCD is really not an electronic device, but rather, is the use of electronics and light. LCD's are made of two layers of polarized glass with laminated conductive surfaces. Between the two layers of glass is a special fluid. This fluid contains "slits" in random arrangement. When neither panes of glass receive current or when both panes of glass receive equal current, the slits remain in a random pattern and light cannot pass through the fluid. However, when greater current is applied to one pane than the other, the slits react to the polarization and the slits orient themselves in a pattern allowing light to pass through the fluid. A bright, halogen bulb is placed behind the display to provide the needed light.


Out of phase square wave voltage applied
Polarized fluid
Bright halogen bulb
When segment opens light passes through
Open segment
+
–
No voltage
Closed segment
Glass sandwich

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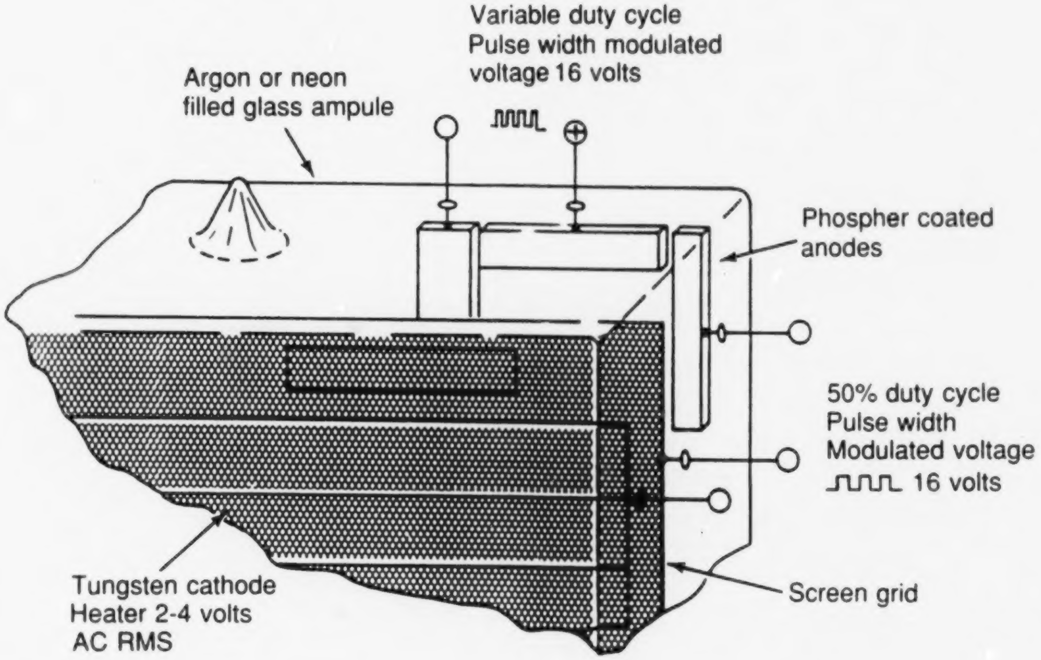
LCD's can be displayed in any shape or arrangement. A colored filter can be placed over the LCD, as is often seen on the portion of speedometers above 55 mph. Disadvantages of LCD use include the special handling necessary when replacing halogen bulbs and the LCD's reaction to extreme temperatures. Halogen bulbs are pressurized and become extremely hot. They should be removed according to manufacturer's directions and with the aid of a special tool. Halogen bulbs and LCD glass ampules should NEVER be touched with your fingers or performance may be altered. LCD's are also affected by temperatures of 20-30 degrees or lower. Their performance is slowed and the ECM's internal clock must be slowed also so the cluster can continue to operate properly.

Vacuum Tube Florescent Display (VTF)

VTF's operate similarly to televisions. Inside a sealed vacuum, a cathode filament releases electrons when heated by current. The electrons are attracted to the other side of the vacuum, where a charged screen and anode are placed. How many electrons hit the anode and where they hit depends on how the voltage of the anode is adjusted in comparison to that of the screen. When electrons strike the anode, energy is produced in the form of light.


Variable duty cycle
Pulse width modulated
voltage 16 volts
Argon or neon
filled glass ampule
Phospher coated
anodes
50% duty cycle
Pulse width
Modulated voltage
16 volts
Tungsten cathode
Heater 2-4 volts
AC RMS
Screen grid

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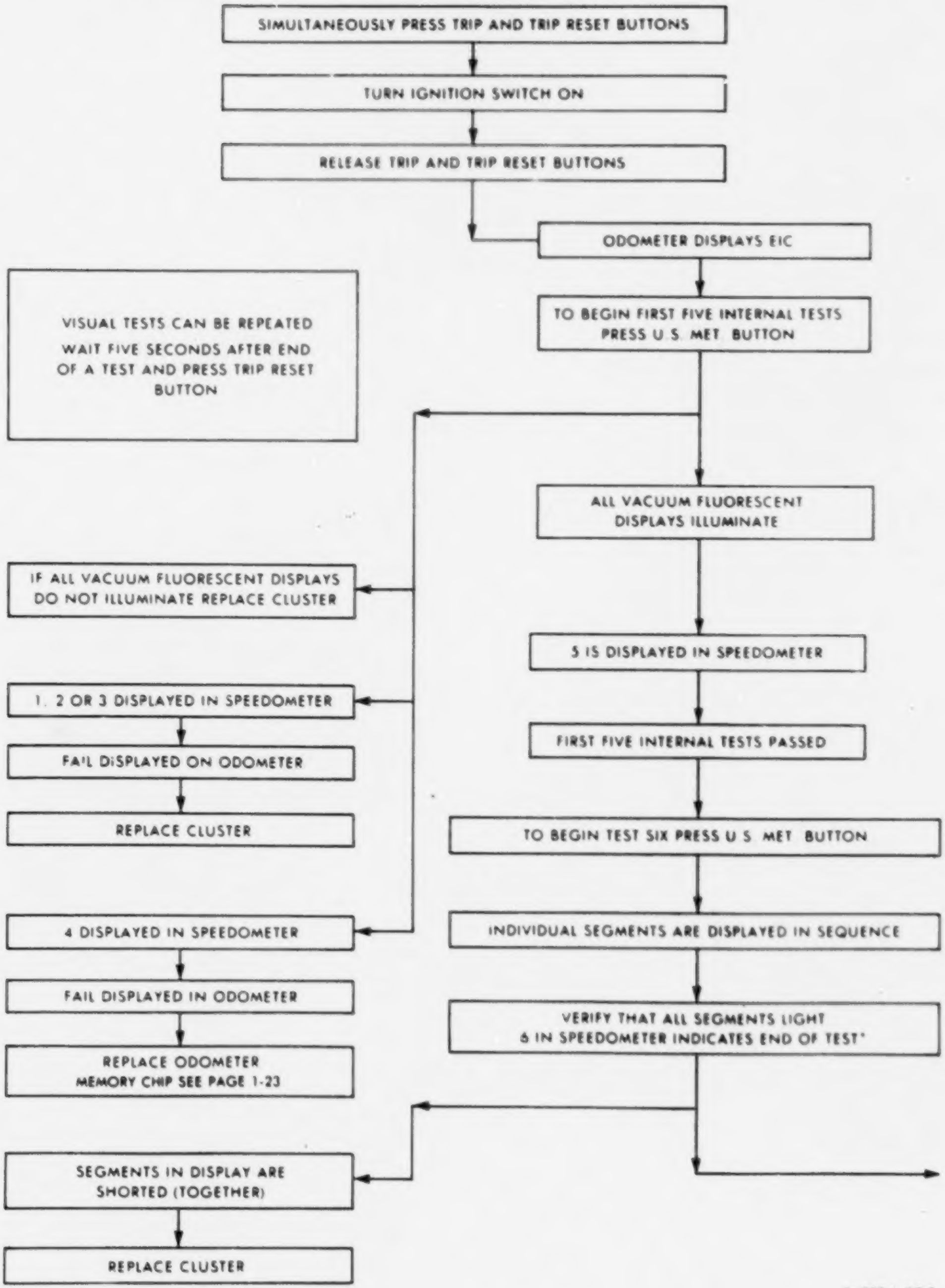
VTF's can produce any picture desired. In some cars, radio signals are sent to satellites which beam a return signal to the car. The car's computer can pick up the signal and calculate the car's position on Earth. A VTF located in the car then shows the driver the car's position on a map of major roads in the area.

VTF's must be very bright to be seen in daylight and may be too bright at night. To correct this, most VTF's are set for daylight viewing, but the automobile's logic unit monitors headlight use and dimmer switch voltage and adjusts the VTF for nighttime use.

K & E BODY
ELECTRONIC CLUSTER WITH TACHOMETER OR MESSAGE CENTER
SELF DIAGNOSTIC TEST


SIMULTANEOUSLY PRESS TRIP AND TRIP RESET BUTTONS
TURN IGNITION SWITCH ON
RELEASE TRIP AND TRIP RESET BUTTONS
ODOMETER DISPLAYS EIC
TO BEGIN FIRST FIVE INTERNAL TESTS PRESS U.S. MET. BUTTON
VISUAL TESTS CAN BE REPEATED WAIT FIVE SECONDS AFTER END OF A TEST AND PRESS TRIP RESET BUTTON
ALL VACUUM FLUORESCENT DISPLAYS ILLUMINATE
IF ALL VACUUM FLUORESCENT DISPLAYS DO NOT ILLUMINATE REPLACE CLUSTER
5 IS DISPLAYED IN SPEEDOMETER
1, 2 OR 3 DISPLAYED IN SPEEDOMETER
FIRST FIVE INTERNAL TESTS PASSED
FAIL DISPLAYED ON ODOMETER
REPLACE CLUSTER
TO BEGIN TEST SIX PRESS U.S. MET. BUTTON
4 DISPLAYED IN SPEEDOMETER
INDIVIDUAL SEGMENTS ARE DISPLAYED IN SEQUENCE
FAIL DISPLAYED IN ODOMETER
VERIFY THAT ALL SEGMENTS LIGHT 6 IN SPEEDOMETER INDICATES END OF TEST*
REPLACE ODOMETER MEMORY CHIP SEE PAGE 1-23
SEGMENTS IN DISPLAY ARE SHORTED (TOGETHER)
REPLACE CLUSTER

SHEET 1 OF 2

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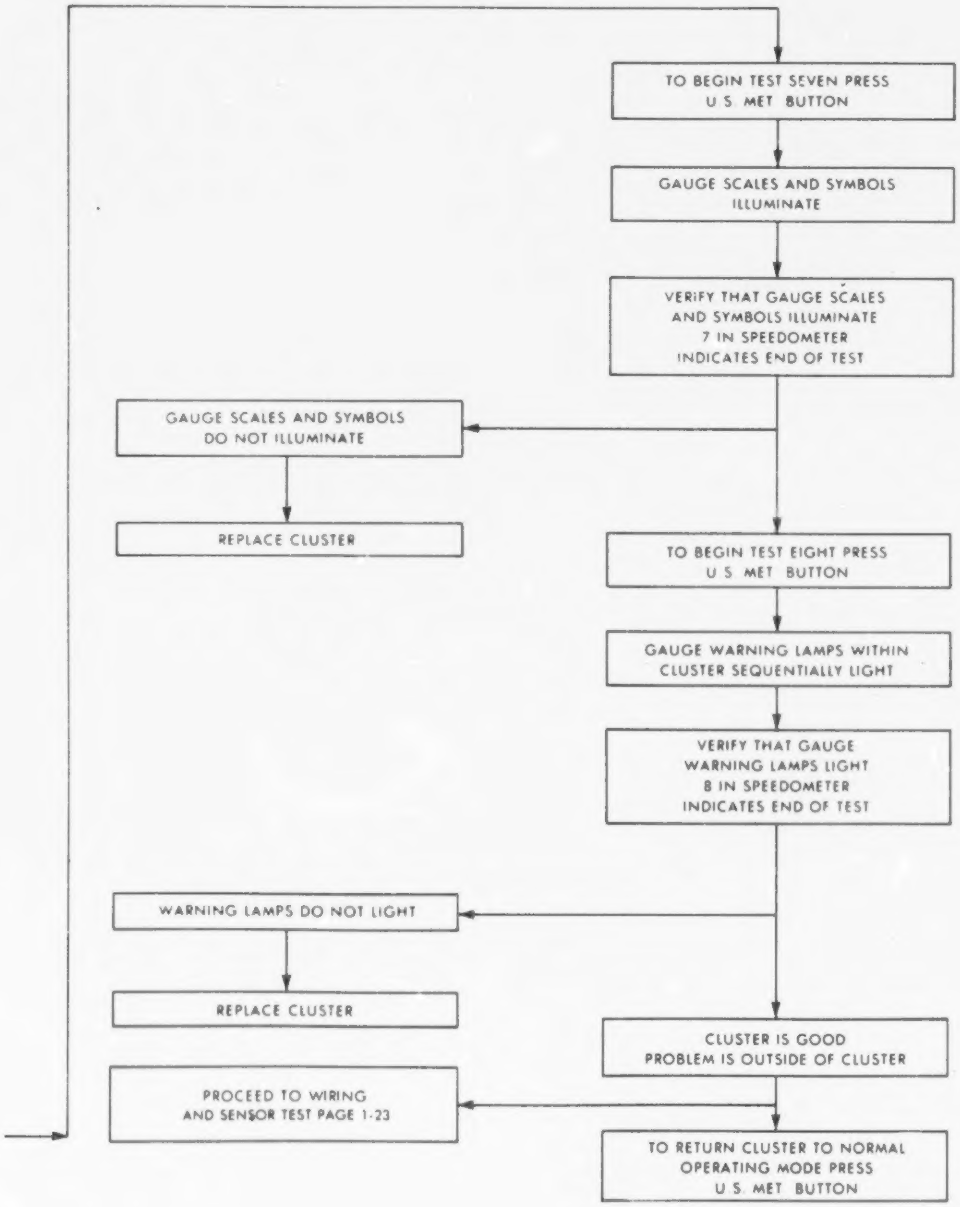
K & E BODY
ELECTRONIC CLUSTER WITH TACHOMETER OR MESSAGE CENTER
SELF DIAGNOSTIC TEST



TO BEGIN TEST SEVEN PRESS U S MET BUTTON
GAUGE SCALES AND SYMBOLS ILLUMINATE
VERIFY THAT GAUGE SCALES AND SYMBOLS ILLUMINATE 7 IN SPEEDOMETER INDICATES END OF TEST
GAUGE SCALES AND SYMBOLS DO NOT ILLUMINATE
REPLACE CLUSTER
TO BEGIN TEST EIGHT PRESS U S MET BUTTON
GAUGE WARNING LAMPS WITHIN CLUSTER SEQUENTIALLY LIGHT
VERIFY THAT GAUGE WARNING LAMPS LIGHT 8 IN SPEEDOMETER INDICATES END OF TEST
WARNING LAMPS DO NOT LIGHT
REPLACE CLUSTER
CLUSTER IS GOOD PROBLEM IS OUTSIDE OF CLUSTER
PROCEED TO WIRING AND SENSOR TEST PAGE 1-23
TO RETURN CLUSTER TO NORMAL OPERATING MODE PRESS U S MET BUTTON

SHEET 2 OF 2

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HUNTSVILLE ELECTRONIC CLUSTERS

FUEL GAUGE

Condition: Fuel gauge inoperative or incorrect reading.

Test cluster using the correct self-diagnostic test. Cluster must pass test before proceeding to next step.

- If gauge reads empty all the time, perform Test A.
- If gauge reads full all the time, perform Test B.
- If gauge readings are not accurate, perform Test C.

Test A

Gauge reads empty all the time; this indicates an **open** between the cluster and fuel tank sending unit or a faulty fuel tank sending unit.

- To diagnose, perform the following steps.

Step I

Remove connector from fuel tank sending unit, connect a jumper wire from G-4 dark blue wire in connector to ground, turn ignition switch to run position (ON), wait for 30 seconds. Gauge should read full.

- Gauge reads full, change fuel tank sending unit.

  NOTE: Check gray wire to ground, also connector before replacing sending unit.

- Gauge reads empty with jumper wire connected, perform Step II.

Step II

- Use Service Manual Wiring Diagram to check for **open** in G-4 dark blue wire to cluster.

Test B

Gauge reads full all the time:

This indicates a **short** to ground between the cluster and fuel tank sending unit or a faulty fuel tank sending unit.

NOTE: If all gauges read maximum, check for disconnected connector in back of electronic cluster.

- To diagnose perform the following steps:

Step I

With ignition switch in run position (ON), remove connector at fuel tank sending unit, wait 30 seconds. If gauge now reads empty, replace sending unit.

- If gauge still reads full, perform Step II.

Step II

With connector at fuel tank sending unit disconnected and ignition off, disconnect the right electronic circuit board connector, cavity 16. Using an ohmmeter, check G-4 dark blue wire; there should be no continuity.

- If you have continuity, check G-4 dark blue wire for short to ground.
- Use service manual wiring diagram to check for short to ground, cavity 16.

Test C

Inaccurate Fuel Gauge Reading:

This indicates a problem with any of the following: fuel tank, fill tube location, plugged or kinked vent line to canister, or fuel tank sending unit.

- To diagnose, perform the following steps:

Step I

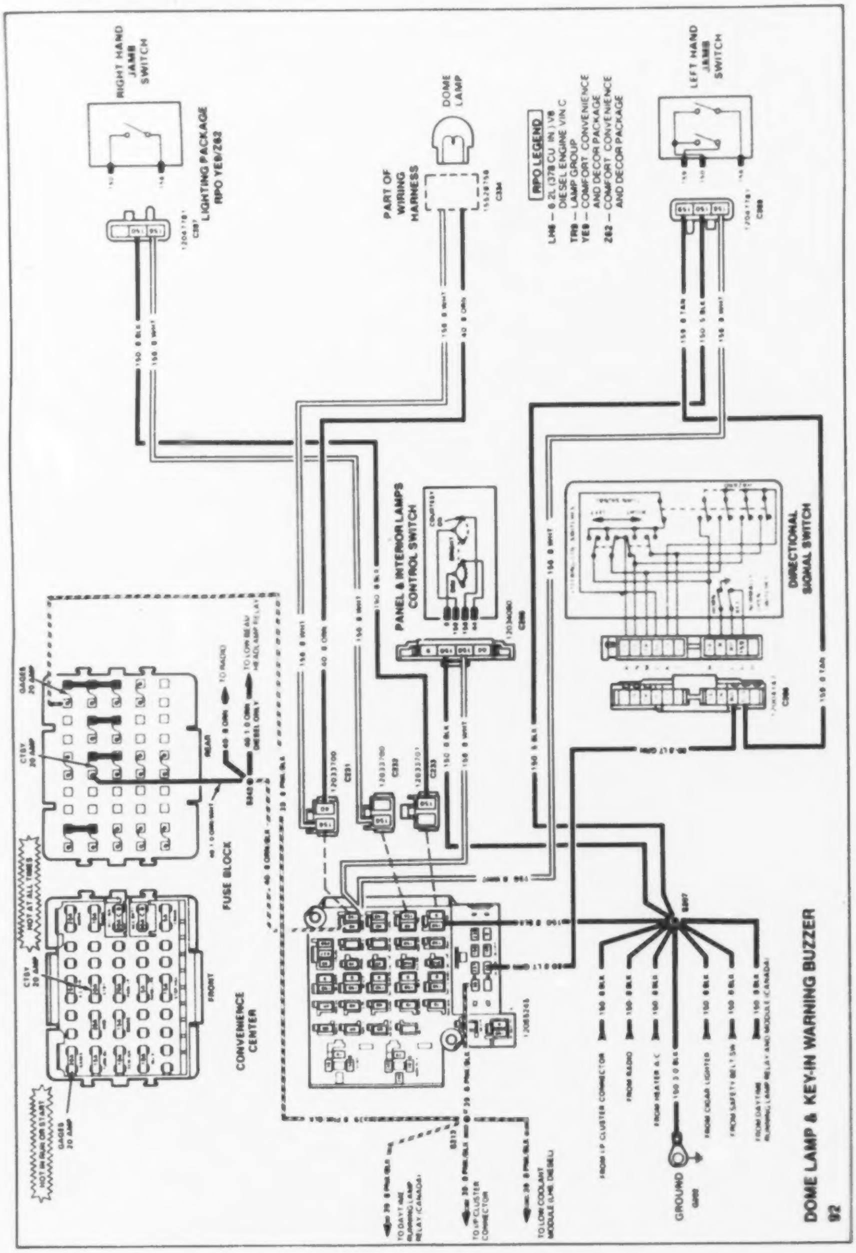
Inspect fuel tank for external damage. If no damage, remove connector from fuel tank sending unit. Turn ignition switch to run position (ON) with connector removed — gauge should show empty.

Next, using a jumper wire, connect one end to the G-4 dark blue wire in the connector, ground the other end of jumper to a good ground. Wait for thirty seconds, gauge should read full.

- If gauge reads empty and full after performing Step I, problem is with sending unit, or fuel tank fill.

- Replace fuel tank sending unit. Check fuel tank for plugged or kinked vapor line to charcoal canister.

WIRING DIAGRAM FOR AUDIBLE ALARM PROBLEMS


RIGHT HAND JAMB SWITCH
LIGHTING PACKAGE RPO YE9/Z82
C397
DOME LAMP
PART OF WIRING HARNESS
C334
RPO LEGEND
LH6 — 6.2L (378 CU. IN.) V8 DIESEL ENGINE VIN C
TR9 — LAMP GROUP
YE9 — COMFORT CONVENIENCE AND DECOR PACKAGE
Z82 — COMFORT CONVENIENCE AND DECOR PACKAGE
LEFT HAND JAMB SWITCH
C398
PANEL & INTERIOR LAMPS CONTROL SWITCH
C286
DIRECTIONAL SIGNAL SWITCH
C280
C231
C232
C233
FUSE BLOCK
CONVENIENCE CENTER
FRONT
REAR
GAGES 20 AMP
CTSY 20 AMP
HOT AT ALL TIMES
HOT IN RUN OR START
TO RADIO
TO LOW BEAM HEADLAMP RELAY
DIESEL ONLY
S207
GROUND
G200
FROM I/P CLUSTER CONNECTOR
FROM RADIO
FROM HEATER A/C
FROM CIGAR LIGHTER
FROM SAFETY BELT SW
FROM DAYTIME RUNNING LAMP RELAY AND MODULE (CANADA)
TO DAYTIME RUNNING LAMP RELAY (CANADA)
TO I/P CLUSTER CONNECTOR
TO LOW COOLANT MODULE (LH6 DIESEL)
DOME LAMP & KEY-IN WARNING BUZZER
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SWITCHES & INSTRUMENT PANELS

CORVETTE ELECTRONIC INSTRUMENT PANEL

DESCRIPTION

The instrument cluster is an electronic, microprocessor controlled unit with liquid crystal displays. Speedometer and tachometer readings are displayed both digitally and in bar graph form. The driver information center is located between speedometer and tachometer.

Information center has an analog (bar graph) fuel gauge display and 4 multi-function digital displays. Displays are switch selectable. Display selections include oil pressure or oil temperature, coolant temperature or system voltage, instant or average fuel economy, trip odometer, range or distance traveled on reserve.

A telltale panel to right of cluster contains indicators for low fuel, oil temperature, low oil pressure, coolant temperature, and low system voltage. To left of telltale panel is a function select switch panel containing 4 function select switches, the English/Metric select switch, the trip odometer/range reset button and average fuel economy reset button.

A photocell located on face of cluster provides ambient lighting information to cluster circuitry which in turn adjusts panel brightness as necessary.

OPERATION

When ignition is turned on, instrument panel lights will initially light with full intensity. Then all analog displays cycle full scale and back to normal reading within 2 seconds. Digital readings associated with analog readings also cycle to normal.

SPEEDOMETER DISPLAY

The speedometer display incorporates both analog and digital readouts. The speedometer signal is produced from transmission mounted Permanent Magnet (PM) generator. Speed reading can be displayed in either English or Metric units.

TACHOMETER DISPLAY

Tachometer display incorporates both analog graph and digital readings. Tachometer signal is generated from HEI distributor.

DRIVER INFORMATION CENTER

Fuel Display

Fuel gauge display is an analog (bar graph) readout. Readout is not affected by the English/Metric switch or function select switch. Fuel level "low telltale light and "on-reserve" features operate when last bar of fuel graph goes out.

Oil Pressure/Temperature Display

Oil pressure and temperature display located in the driver information center is a 3-digit display. It is capable of displaying either oil pressure or temperature in English or Metric units. A telltale feature has been incorporated in this display for both functions.

Coolant Temperature/System Voltage Display

Display located in driver information center is switch selected to display coolant temperature or system voltage in English or Metric units. A telltale feature has been incorporated in this display.

Fuel Economy Display

Fuel economy display will display either instantaneous or average fuel economy. Display will display range or trip distance in either English or Metric units.

When the last bar of the fuel display goes out, the "on-reserve" function is implemented and "low" fuel telltale is turned on. When "on-reserve" function is implemented, display will show distance traveled since "on-reserve" function was implemented.

Telltales

There telltales have been incorporated into driver information center to serve as warning signals if an "out of normal range" condition occurs on any of the following 5 functions: oil pressure, oil temperature, coolant temperature, system voltage, and fuel level.

One telltale serves as the "low" fuel level warning, and the other two are shared by the oil pressure/temperature telltale and the coolant temperature/system voltage telltale.

Dimming

Instrument panel dimming depends upon both photocell input and dimmer rheostat setting. The photocell measures brightness of daylight. Its input is added to rheostat setting (if parking lights are on) to determine the amount of dimming for displays. In the event a telltale light comes on, indicating an "out of range" condition, maximum display brightness will occur.

TESTING & DIAGNOSIS

SYSTEM CHECK

Indicators

1. Turn ignition switch to "ON" position. Open doors. Door ajar indicator should come on. Close doors. Door ajar indicator should go off. Open hatch. Hatch ajar indicator should come on. Close hatch. Indicator should go off.

2. Turn ignition switch slowly past the "ON" position. Brake warning indicator should come on before ignition switch reaches start position. With ignition switch in "ON" position, put parking brake on. Brake warning indicator should come on.

3. Turn ignition off. Open doors. Security indicator should come on. Close doors. Security indicator should go off. Turn ignition switch to "START" position. Fasten seat belt indicator should come on for 4-8 seconds.

Digital Cluster

1. Turn ignition switch to "ON" position. All display should light to full brightness for 2 seconds. All analog bar graph displays

should cycle from a full scale to a normal reading in 2 seconds. All digital display readouts cycle to present readings.

2. Choose each function of the function select switches. Change cluster from English to Metric display. All readouts, except fuel display, should appear in both English and Metric units.

3. Shine a flashlight or drop light at digital cluster. Digital display brightness should increase in response to photocell. Place light switch in "PARK" position. Adjust instrument panel dimmer. Digital display brightness should change as dimmer is turned.

4. Turn dimmer down to minimum brightness. Shine a light on digital cluster once again. Digital display should dim as dimmer is turned down, then get brighter when light is shined on cluster.

FIGURE 1 Corvette Electronic Instrument Panel Symptom Chart

Digital Cluster and Indicators Cluster Symptom		Action
ENTIRE DIGITAL DISPLAY	Does not light up.	Check D1, C16, D5 and D16.
	Does not dim.	Check C9, C6.
	Is hard to read.	Replace digital cluster.
	Is always minimum brightness with lights on.	Check C9, C6.
	Stays on, all segments.	Check all grounds.
	Bar graphs partly lit up.	Check all grounds.
	Has unusual display.	Check all grounds, also C16, D16.
SPEEDOMETER/ODOMETER	Speedometer does not operate, odometer OK.	Replace cluster.
	An odometer does not operate, speedometer OK.	Replace digital cluster.
	Speedometer and both odometers do not operate.	Check D11, C15.
	Speedometer bar graph operates but the digital display does not.	Replace digital cluster.
	Trip odometer does not reset to zero.	Check A4.
	Trip odometer resets each time ignition switch goes off.	Check D5.
TACHOMETER	No tachometer display.	Check C5.
	Tachometer bar graph operates but the digital display does not.	Replace digital cluster.

Digital Cluster and Indicators Cluster Symptom		Action
DRIVER INFORMATION DISPLAYS	No "LOW FUEL" indicator when tank is low.	Replace digital cluster.
	Display shows E with fuel in tank, one bar lit.	Check C8.
	"OIL TEMP" display is not accurate.	Check D6.
	"VOLTS" display is not accurate.	Replace digital cluster.
	"OIL PRESSURE" display shows low with oil pressure good.	Check C1.
	"OIL PRESSURE" display always high.	Check C1.
	Coolant "TEMP" gage low with engine warm.	Check D4.
	Coolant "TEMP" gage always high.	Check D4.
TELLTALE BULB INDICATORS IN DIGITAL CLUSTER	No hi beam indicator.	Check C3, also check replaceable bulb.
	No left or right turn signal.	Check C2, C4, also check replaceable bulb.

Courtesy of General Motors Corp.

SYSTEM DIAGNOSIS

Symptom Test Chart

1. Verify complaint by using SYSTEM CHECK. Use the CORVETTE ELECTRONIC INSTRUMENT PANEL SYMPTOM CHART to decide whether instrument cluster must be returned for repair or if there is a problem in vehicle circuitry.

2. If symptom is not in CORVETTE ELECTRONIC INSTRUMENT PANEL SYMPTOM CHART, test all terminals of the digital cluster connectors or the indicator connector. See CORVETTE ELECTRONIC INSTRUMENT PANEL VOLTAGE & RESISTANCE TEST.

Voltage & Resistance Test

This test lists all the voltage and resistance values that you should find at the digital cluster connectors or the indicator connector.

- Measure all voltages to ground with ignition switch in "ON" position.

- Measure all resistances to ground with ignition off, and negative battery cable disconnected.

- Check that all terminals in connectors are properly seated and not pushed out of connector.
- Check all ground terminals with a self-powered test light before making voltage or resistance measurements. If correct voltage or resistance is found at a terminal, and the cluster function that uses that terminal does not operate, replace digital cluster.

FUEL DISPLAY

Fuel Display Shows Empty When Tank is Full (Caused By Short in Circuit)

1. Disconnect fuel tank sending unit connector. Place ignition switch in "0N" position. If fuel display shows full, replace fuel tank sending unit.
2. If fuel display still shows empty, check circuit (Pink wire) back to instrument panel connector. Check terminal C8 for short. If circuit is okay and fuel display connections are good, replace the instrument cluster.

Fuel Display Inaccurate

1. Disconnect fuel gauge sender connector. Connect one Red clip lead of Instrument Panel Tester (J-33431) to terminal B (Pink wire). Connect the other clip to terminal A (Black wire) of the harness half. Set dials of tester to zero ohms, at 45 ohms, and then at 90 ohms. The fuel gauge should display "EMPTY," "1/2," and then "FULL."
2. If fuel gauge responds correctly, replace the gauge sender. If fuel gauge does not respond correctly, check Pink wire to the instrument cluster printed circuit for high resistance. If okay, replace the instrument cluster.

Fuel Display Shows Full Constantly

1. Check fuel tank sending unit ground and ground connection. If ground connections are okay, connect fused jumper wire between grounds and Pink wire of fuel tank sending unit connector.
2. Turn ignition switch to "ON" position. If fuel display now reads empty, replace fuel tank sending unit. If display still reads full, check circuit (Pink wire) back to instrument panel connector.

Check terminal C8 for open. If circuit is okay, check fuel display connections. If connections are good, replace the instrument cluster.

COOLANT TEMPERATURE DISPLAY

Shows Hot When Engine Is Cold (Caused By Short In Circuit)

1. Remove connector from coolant temperature sensor. If display shows cold, the wiring is good. Replace coolant temperature sensor. The sensor was shorted to ground.

2. If coolant temperature display remains hot, check for short in circuit (Dark Green wire) back to instrument panel. If circuit and connections are good, replace instrument panel.

Shows Cold When Engine Is Warm Or Hot (Caused By Open In Circuit)

1. Remove connector from coolant temperature sensor. Connect fused jumper wire from connector Dark Green wire to ground. Place ignition switch in "ON" position.

2. If coolant temperature display now reads 330°F (166°C), replace the coolant temperature sending unit. If the coolant temperature display does not indicate 330°F (166°C), check Dark Green wire for an open. If the Dark Green wire is okay, replace the instrument cluster.

OIL PRESSURE DISPLAY

1. If the oil pressure display does not read correctly, remove connector with Tan wire from oil pressure sending unit. Clip one lead of Instrument Panel Tester (J-33431) to connector and other lead to ground.

2. Place ignition switch in run position. Set resistance control on tester to zero ohms. Display should read zero psi. Set resistance control to 45 ohms. Display should read within 40-46 psi (2.8-3.2 kg/cm^2). Set resistance control to 90 ohms. Display should read within 77-83 psi (5.4-5.8 kg/cm^2).

3. If display reads correctly, install a new oil pressure sending unit. If display does not read correctly, disconnect tester and check Tan wire for high resistance. If wiring is good, replace instrument panel.

VOLTS DISPLAY

If volts display is not working properly, compare display value with actual battery voltage. If the 2 readings are different, replace instrument panel. See REMOVAL & INSTALLATION in this article.

SPEEDOMETER

1. Remove connector from speed sensor. Connect mating cable from Instrument Panel Tester (J-33431) to connector just removed. Plug in tester and set to "60 Hz," with ignition switch in "ON" position.

2. Speedometer should indicate 54 MPH. If speedometer indicates correctly, replace speed sensor. If speedometer reading is incorrect, check sensor wires and connections to instrument panel. If wiring and connections are good, replace cluster.

TACHOMETER

1. If either bar graph or the number display does not work properly, replace the instrument panel. If both bar graph and the number display do not work, remove White wire connector from distributor.

2. Connect Instrument Panel Tester (J-33431) between White wire connector of distributor and ground. Set tester controls to "ON" and "54 MPH." The tachometer should indicate 900 RPM. If tachometer indicates correctly, wiring and indicator are okay. Repair or replace distributor.

3. If tachometer reading is incorrect, check White wire for an open. If wire is okay, replace instrument cluster.

OIL TEMPERATURE DISPLAY INDICATES COLD CONSTANTLY

Remove connector to oil temperature sensor. Ground Dark Green/White wire. Turn ignition on. If oil temperature display indicates 330°F (166°C), replace sensor. If reading is still cold, check Dark Green/White wire from sensor to cluster for an open. If wire and connections at cluster are good, replace instrument panel.

OIL TEMPERATURE DISPLAY INDICATES HOT CONSTANTLY

Remove connector to oil temperature sensor. Turn ignition on. If oil temperature display indicates cold, replace sensor. If reading is still hot, check Dark Green/White wire from sensor to cluster for a short. If wire and connections at cluster are good, replace instrument panel.

FUNCTION DISPLAY SWITCH

1. If display does not work correctly, disconnect telltale assembly connector from instrument cluster. Locate wire terminal of the function that does not operate properly. Measure resistance between that terminal and terminal B1, with the switch being tested in the "OFF" position. If resistance is infinite ohms, go to step 2. If resistance is zero ohms, replace the faulty switch or entire telltale assembly.

2. With ohmmeter still connected between the suspect switch terminal, and terminal B1. Hold the suspect switch in position to select the desired function. If resistance is infinite ohms, replace the faulty switch or entire telltale assembly. If resistance is zero ohms, replace instrument cluster.

ODOMETER DISPLAYS

If trip and range displays in cluster do not work and speedometer display is good, replace instrument panel. If mechanical total odometer does not work, remove cluster and inspect wires and connector to odometer motor. If wiring is okay, replace instrument panel.

DOOR AJAR INDICATOR

Remains On With Ignition Switch in Run and Both Doors Closed Securely

1. Disconnect connectors, one at a time, to both of the switches controlling the indicator. If indicator does not go out, check wiring between telltale assembly and each switch for a short to ground. If wiring is good, check connections to bulb inside telltale assembly.

2. If indicator light goes out, check the switch where connector removal caused the light to go out. Check for short to ground at connector terminal. If this check is good, replace suspect switch.

Does Not Come on With Ignition Switch in On, or Start, With Door Ajar

Place ignition switch in "ON" position. Disconnect connector to both switches, and ground connectors one at a time. If door ajar indicator comes on, check the switch where grounding the connector caused the indicator to light. Check for an open at switch connections. If connections are good, replace suspect switch. If grounding connectors to switch does not light the indicator, check wiring for an open.

LOW COOLANT INDICATOR

Comes On With Correct Coolant Level

1. Remove connector to low coolant probe. If indicator light goes out, replace low coolant probe. If indicator light stays on, remove connector to low coolant module.

2. If indicator light goes out, check Dark Green wire from low coolant probe to terminal F of low coolant module connector for a short to ground. If Dark Green wire is okay, replace low coolant module.

3. If indicator light stays on, check Gray wire for short to ground from terminal E of low coolant module connector to terminal No. 13 of telltale assembly connector. Also check connections to bulb inside telltale assembly for shorts.

Does Not come On With Low Coolant Level

1. Remove connector from low coolant probe and ground connector. If indicator lights, replace low coolant probe. If indicator does not light, check bulb. If bulb is good, go to next step.

2. Ground terminal F of low coolant module. If indicator light comes on, locate short in Dark Green wire, between probe and module. If indicator does not light, go to next step.

3. Ground terminal E of low coolant module. If indicator light comes on, replace low coolant module. If indicator does not light, remove telltale assembly and check Gray wire for opens between module and telltale assembly. Also check connections to bulb inside telltale assembly.

HATCH AJAR INDICATOR

Does Not Light With Hatch Open

1. With hatch open, measure resistance across ajar switch. If resistance is infinite ohms, replace hatch ajar switch. If resistance is close to zero ohms, check for continuity between telltale assembly connector, terminal No. 10 (Gray) and switch Black wire. Also check Black wire to ground.

2. If there is continuity, check connections to bulb inside telltale assembly. If there is no continuity, locate open in either Black wire, Gray wire, or bulb connections. Replace diode module if wires and connections are okay.

Always Lit

With hatch closed, measure resistance across hatch ajar switch. If resistance is close to zero ohms, replace switch. If resistance is infinite ohms, check for short to ground in Black wire from switch to diode module and in Gray wire from diode module to telltale assembly. Check connections to bulb inside telltale assembly. Replace diode module if wires and connections are okay.

REMOVAL & INSTALLATION

MAIN INSTRUMENT CLUSTER

Removal & Installation

1. Disconnect negative battery cable. Remove light switch knob and light switch nut. Remove steering column trim cover. Remove 2 steering column attaching bolts and lower steering column.

2. Remove cluster bezel front and left side attaching screws. Remove cluster bezel from instrument panel. Remove 4 screws attaching cluster to instrument panel. Pull cluster rearward and disconnect cluster electrical connectors. Metal retaining clips are located at back side of connectors.

3. Remove cluster from instrument panel. Odometer may be removed for service or replacement. To install instrument cluster, reverse removal procedure.

INSTRUMENT PANEL PAD

Removal and Installation

Disconnect negative battery cable. Remove instrument panel cluster bezel. Remove steering column tilt lever. Remove 5 screws attaching instrument panel pad to carrier. Remove 2 screws at defroster ducts. Remove instrument panel pad. To install pad, reverse removal procedure.

RIGHT LOWER INSTRUMENT PANEL TRIM PAD

Removal and Installation

1. Disconnect negative battery cable. Remove instrument panel trim pad. Remove right side close out panel. Remove right trim and fuse plate. Remove right flexible A/C hose and duct.

2. Remove 2 screws at carrier to side glass defroster hose. Remove right front trim pad. Remove right lower carpeted panel. To install pad, reverse removal procedure.

RIGHT FRONT INSTRUMENT PANEL TRIM PAD

Removal and Installation

1. Disconnect negative battery cable. Remove instrument panel cluster bezel and remove instrument panel pad. Remove right close out panel. Remove right instrument panel trim and fuse panel plate.

2. Remove right flexible A/C hose and duct. Remove 2 screws at hose from carrier to side glass defroster hose. Remove right front trim pad. To install pad, reverse removal procedure.

INSTRUMENT PANEL CONSOLE TRIM PLATE

Removal and Installation

Disconnect negative battery cable. Remove 2 screws at lower portion of instrument panel bezel. Remove shift knob. Remove console plate attaching screws and disconnect bulb connectors.

Remove console plate. To install trim plate, reverse removal procedure.

INSTRUMENT PANEL CARRIER

Removal and Installation

1. Disconnect negative battery cable. Remove instrument panel cluster bezel. Remove 5 screws attaching instrument panel pad to carrier. Remove 2 screws at defroster ducts. Remove instrument panel pad.

2. Remove 4 left side close out panel attaching screws. Disconnect electrical connector at courtesy light and remove panel. Remove 4 right side close out panel attaching screws.

3. Disconnect electrical connector at courtesy light and remove panel. Remove 4 right side instrument panel trim screws and fuse cover. Remove 4 upper dash brace attaching screws and remove brace. Remove right side flexible A/C duct hose and duct.

4. Remove 2 screws at instrument panel to side glass defroster hose. Remove right side trim pad. Remove right lower carpeted panel. Remove radio. Remove 4 screws to center cluster and carrier. Disconnect wire connectors at main cluster. Metal retaining clips are located at back side of connectors.

5. Remove center cluster. Remove 4 main cluster screws. Remove console bezel and shift handle. Disconnect bulb connector. Remove 4 screws attaching A/C control panel to instrument panel and push control panel through opening.

6. Remove headlight switch attaching nut. Remove fog light switch. Remove trim piece at hood release handle. Remove steering column trim piece and 2 steering column attaching bolts. Remove 2 bolts attaching carrier to console. Remove 2 nuts at upper sides of console and 2 bolts at lower sides.

7. Disconnect fuse block from carrier. Remove center A/C duct. Remove left A/C duct and 2 screws attaching carrier to defroster duct. Remove screws from harness to backside of carrier and to left side of defroster hose at column brace. Remove carrier. To install carrier, reverse removal procedure.

ODOMETER MODULE

Removal

Remove main instrument cluster and odometer module. See MAIN INSTRUMENT CLUSTER in this article.

Replacement

1. Remove electric stepper motor from failed assembly and install on new frame. Tighten screws. If odometer is to be replaced indicating actual milage, remove White plastic retainer from pinion carriers on new odometer.
2. Start at left and hold pinion carriers of wheels that do not need resetting. For the first wheel needing resetting, hold pinion carrier immediately to the right and rotate next wheel clockwise. Each revolution will cause adjacent left wheel to index one position.
3. Continue this process until correct digit is displayed, and repeat with each wheel to the right until correct mileage is displayed. Install breakable retainer to pinion carriers and recheck mileage after all pinion carriers have been aligned.

Installation

1. Place new odometer in new frame, making sure gear teeth are engaged between motor and odometer and that pinion carriers are in frame channel. Place 2 new brass retainer plates over plastic pins on each end of frame bearings.
2. Use a soldering iron or other heat source to reshape plastic pins, while holding retainers in place against frame. Connect motor terminal to Instrument Panel Tester (J-33431) to check operation. To complete installation, reverse removal procedure.

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REPORT ON DRIVERS' PREFERENCES FOR INFORMATION SYSTEMS

READ CONSUMER MAGAZINES

Read a consumer magazine such as *Consumer Reports* and make a chart showing their evaluation of information systems of five different models. Present the results of your research to your class as a poster or in an oral report.

SURVEY AUTO SALES PERSONNEL

Talk to sales representatives about the driver information systems their customers prefer. Automobiles from at least three different companies should be compared. Display your results on a poster or chart.

QUESTION NEW AUTO OWNERS

Ask three new automobile owners if the driver information system was an important factor in choosing their new cars. Also ask them if they would prefer another driver information system or components not included in their cars. Present the information to your class as an oral report, a poster, or a chart.

ASSIGNMENT SHEET 1

DRIVER INFORMATION SYSTEMS

VIII

NAME ______________________________ SCORE ________

OBJECTIVE 8 **Diagnose warning light systems.**

INTRODUCTION

Diagnosis of Driver Information Systems varies greatly among makes and models depending upon the electronic circuitry in the car and the components in the Driver Information System. Most systems are electronically diagnosed and include self-test programming. Before testing the Driver Information System, consult the manufacturer's service manual.

The information for this exercise covers problems in a Chrysler K or E Body. If we were actually servicing the automobile, this test would not be conducted until we had visually checked the cluster. After starting the car, we would check to see if the cluster lit. If it did not light, fuses, battery voltage, and ignition voltage should all be checked at the connector pins. If voltage is registered at all three pins, the cluster should be replaced.

If single components do not operate correctly within a cluster, this diagnosis should be run before the component is tested. Some optional cluster components may have to be tested separately.

DIRECTIONS

Use the flow charts in Supplement 2 to answer the questions below.

1. Is the car running when the test procedure is started? ________
2. What display should be checked before beginning the first five internal tests? ______________________ What should it display? __________
3. What part should be replaced if "4" is displayed in the odometer? ______________________________________

____

4. What displayed in the speedometer indicates the end of Test 6? __________

5. What should illuminate in Test 7? ____________________________

____

6. What is the proper service if warning lamps do not light?

____

ASSIGNMENT SHEET 2

DRIVER INFORMATION SYSTEMS

VIII

NAME ______________________________ SCORE ________

OBJECTIVE 9

Complete a gauge system troubleshooting chart.

INTRODUCTION

Suppose the test conducted in Assignment Sheet 1 had been requested because the fuel gauge did not operate properly. First testing procedures covered in Assignment Sheet 1 would be performed. If the rest of the system checked out, it would indicate that the problem is not in the cluster, but in the component itself.

Once again, testing procedures will vary and should be conducted following the manufacturer's service manual. This activity will again use the procedures for a Chrysler K & E Body and will assume the Self-Diagnostic Test has already been performed.

DIRECTIONS

Use the instructions found in Supplement 3 to make a troubleshooting chart. Fill in the blank squares.

Symptoms	Cause	Action

ASSIGNMENT SHEET 3

DRIVER INFORMATION SYSTEMS

VIII

NAME ________________________________ SCORE ________

OBJECTIVE 10

Diagnose electronic indicator problems.

INTRODUCTION

Electronic indicators reflect the readings of sensors placed throughout the car. Each sensor is specially designed to best carry out its function. Consequently, testing and diagnosing a problem with electronic indicators must be done according to service manual instructions.

In this Assignment Sheet, we will use the service manual to diagnose Corvette indicator problems.

DIRECTIONS

Find a service manual covering Corvette Instrument Panels. Use the information in the service manual to answer the questions below.

______1. If the Oil Pressure Display reads incorrectly, the connector with a tan wire should be removed from the oil pressure sending unit. An Instrument Panel Tester should be connected to ___.

a. the connector and the display
b. the connector and ground
c. the display and ground

______2. When testing the Oil Pressure Display, with the ignition switch in ON, and a resistance control tester set to 45 ohms, the display should read ___.

a. 0 psi
b. 40-46 psi
c. 77-83 psi

______3. If the Volts Display does not match actual battery voltage, can the Volts Display be repaired?

a. No, it must be replaced.
b. Yes, it is a simple adjustment.
c. Yes, but only if the battery is replaced.

______4. If the Oil Temperature Display indicates cold all the time, what color is the wire that should be checked?

a. Dark green.
b. White.
c. Dark green and white.

______5. If the Telltale Assembly Connector is disconnected to check the High Beam Indicator, what terminal of the connector should be checked?

a. Light green 11
b. C3
c. 11

______6. If the Telltale Assembly Connector is disconnected and resistance between terminal D7 and B1 is zero ohms the ___.

a. Ambient Temperature Override switch is functioning properly
b. ground at B1 is loose
c. Ambient Temperature Override switch should be replaced

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ASSIGNMENT SHEET 4

DRIVER INFORMATION SYSTEMS

VIII

NAME ______________________________ SCORE ______

OBJECTIVE 11 **Diagnose audible alarm problems.**

INTRODUCTION Audible alarms work within the circuit in much the same manner as lights or other switch-operated units. They are usually affected by the same problems: opens in the circuit, high resistance, and grounds.

DIRECTIONS Use the wiring chart in Supplement 4 to locate the circuitry listing in the troubleshooting chart below. Circle each connection site and write the step number next to it.

KEY-IN WARNING BUZZER DOES NOT OPERATE

TEST	RESULT	ACTION
1. Insert key in ignition switch and open left hand door. Connect a test lamp from PNK/BLK (39) wire at convenience center to ground.	Test lamp lights.	GO to step 2.
	Test lamp does not light.	CHECK condition of fuse (GAGES). If fuse is good, LOCATE and REPAIR open in PNK/BLK (39) wire.
2. Connect a test lamp from LT GRN (80) wire at directional signal switch connector C206 to ground.	Test lamp lights.	GO to step 3.
	Test lamp does not light.	LOCATE and REPAIR open in LT GRN (80) wire. If wire is good, REPLACE seat belt buzzer.
3. Connect test lamp from TAN (159) wire at directional signal switch connector C206 to ground.	Test lamp lights.	GO to step 4.
	Test lamp does not light.	REPLACE directional signal switch.

TEST	RESULT	ACTION
4. Disconnect left hand jamb switch connector C288. Connect ohmmeter from TAN (159) terminal to BLK (150) terminal on jamb switch.	A reading of 0 ohms	Close door. If reading stays at 0 ohms, REPLACE jamb switch. If reading is infinite GO to step 5.
	A reading of infinite ohms.	REPLACE left hand jamb switch.
5. Connect ohmmeter from BLK (150) wire at left hand jamb switch connector C288 to ground.	A reading of 0 ohms.	LOCATE and REPAIR open in TAN (159) wire from jamb switch to directional signal switch.
	A reading of infinite ohms.	LOCATE and REPAIR open in BLK (150) wire from jamb switch to ground terminal G202.

Used with permission of General Motors Corporation.

ASSIGNMENT SHEET 5

DRIVER INFORMATION SYSTEMS

VIII

NAME ______________________ SCORE ________

OBJECTIVE 12 **Diagnose voice notification system problems.**

INTRODUCTION

Although Voice Notification Systems seem like something out of the future, they have are actually very similar to other units. Testing is also very similar and consists of the same basic processes: create the conditions for it to operate and observe how it functions; isolate and test unit components to locate the fault; repair or replace as necessary.

DIRECTIONS

Locate Voice Notification System information for a Chrysler in a service manual. You may need to look under "Switches and Instrument Panels" and Chrysler uses the term "Electronic Voice Alert" (EVA). Use the instructions there to determine how you would diagnose a problem with the "Your Headlights Are On" Circuit. List each step you would take. Include steps taken in Demonstration Mode.

Manual used

Page No.

577

ASSIGNMENT SHEET 1

1. No
2. Odometer
   "EIC"
3. Odometer memory chip
4. 6
5. Gauge scales and symbols
6. Replace cluster

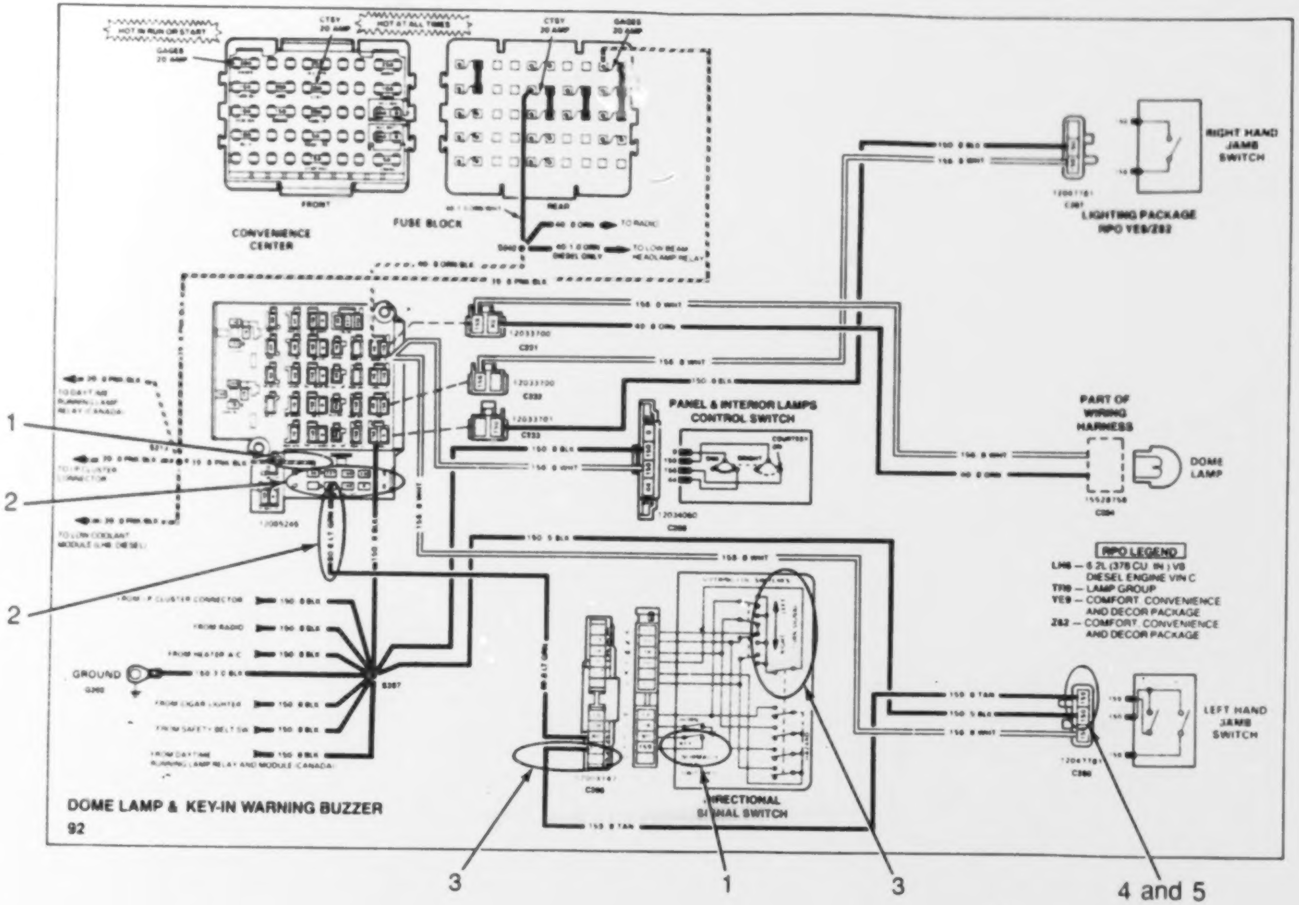
ASSIGNMENT SHEET 2

SYMPTOM	CAUSE	ACTION
Fuel gauge always reads EMPTY	Open between cluster and sending unit or faulty sending unit	Disconnect sending unit connector. Connect a jumper wire to G-4 DB wire and ground. Turn ignition to RUN, wait 30 seconds. If gauge reads FULL, replace sending unit. If gauge reads EMPTY, find open in wire G-4 DB to cluster.
Gauge always reads FULL	Ground between cluster and sending unit or faulty sending unit	Turn ignition to RUN. Disconnect sending unit connector. Wait 30 seconds. If gauge reads EMPTY, replace sending unit. Turn ignition to OFF. Disconnect right circuit board connection cavity 16. Check G-4 DB with an ohmmeter. If continuity is good, check G-4 DB for ground. If continuity is not good, check cavity 16 for ground.
All gauges read MAXIMUM	Disconnected cluster connector	Check and reconnect cluster connectors

Gauge readings are inaccurate	Fuel tank damage, fill tube location problems. Vent line kinked or plugged, sending unit faulty	Inspect fuel tank for damage. If no damage, disconnect sending unit connector. Turn ignition to RUN. Gauge should read EMPTY. Connect a jumper wire to G-4 DB in connector and the other end to ground. Wait 30 seconds; gauge should read FULL. If gauge reads EMPTY then FULL, replace sending unit and check vapor line for kinks or plugs.

ASSIGNMENT SHEET 3

1. b
2. b
3. a
4. c
5. b
6. c


HOT IN RUN OR START
HOT AT ALL TIMES
CTSY 20 AMP
GAGES 20 AMP
FRONT
REAR
CONVENIENCE CENTER
FUSE BLOCK
TO RADIO
TO LOW BEAM HEADLAMP RELAY
RIGHT HAND JAMB SWITCH
LIGHTING PACKAGE RPO YE9/Z62
PANEL & INTERIOR LAMPS CONTROL SWITCH
PART OF WIRING HARNESS
DOME LAMP
RPO LEGEND
LH6 — 6.2L (378 CU. IN.) V8 DIESEL ENGINE VIN C
TR9 — LAMP GROUP
YE9 — COMFORT, CONVENIENCE AND DECOR PACKAGE
Z62 — COMFORT, CONVENIENCE AND DECOR PACKAGE
LEFT HAND JAMB SWITCH
DIRECTIONAL SIGNAL SWITCH
GROUND
DOME LAMP & KEY-IN WARNING BUZZER
92
1
2
2
3
1
3
4 and 5

BEST COPY AVAILABLE

ASSIGNMENT SHEET 5

1. Close all doors, turn off headlights, and remove key from ignition.
2. Wait 1 minute; open driver's door and press door ajar button. Hold button to hear all messages.
3. Make sure connectors are tightly installed and that none are pushed out.
4. Test ground circuit and module battery feed.
5. Test left door ajar switch, wiring, and courtesy lamp switch.
6. After each circuit is serviced, activate demonstration mode.
7. If all circuits test good, voice alert module should be replaced.
8. Turn on ignition, then turn it off. Remove key, pull headlight switch on, open driver's door.
9. If no message is heard, connect the voice alert module connector to a known good chime.
10. Replace voice alert module or repair headlight-to-module circuit.

JOB SHEET 1

DRIVER INFORMATION SYSTEMS

OBJECTIVE 13a **Inspect and service warning lights.**

TOOLS AND EQUIPMENT

- Service manual
- Diagnostic tools required by manufacturer
- Multimeter
- Test lamp
- Safety glasses
- Seat covers
- Floor mats

NOTE: Warning lights vary widely in their function and operation. Use service manual instructions to determine what service procedures are necessary. This is a brief outline for servicing a Chrysler Oil Pressure warning light and should not be used as the procedure for any other make or system.

PROCEDURE **Testing and Diagnosis**.

1. Use service manual or owner's manual to determine what warning lights are in place in the automobile.

2. Activate each warning light and observe its performance. Many warning lights should come on briefly when the ignition is turned to the ON position. Correct the situation and see if the warning light goes out.

3. Perform the following:

   a. If the lamp does not come on, check the light or display and replace as indicated.

   b. If the warning light goes on, start the engine and let it idle. The warning light is functioning correctly if it remains lit for a short time then goes out.

   c. If the lamp stays on, check the circuit for grounds. If no grounds are located, check oil level and oil pressure as indicated in service manual.

   d. If everything tests out as correct, replace warning system switch.

4. Have your instructor check your work.

5. Put away tools and materials and clean the work area.

JOB
SHEET 2

DRIVER INFORMATION SYSTEMS

VIII

OBJECTIVE 13b **Inspect and service gauges.**

TOOLS AND EQUIPMENT

- Service manual
- Jumper wires
- Safety glasses
- Floor mats
- Seat covers

NOTE: Gauges may be tested in a variety of ways. Some gauges are tested by measuring the coil voltage. Others require more extensive testing. This Job Sheet lists the basic procedures for testing for opens. Gauges vary in performance and service. No service or testing should be performed unless prescribed in the service manual.

PROCEDURE

1. Consult a service manual and follow instructions.
2. Have your instructor check your work.
3. Put away tools and materials and clean the work area.

OBJECTIVE 13c **Test electronic indicators.**

TOOLS AND EQUIPMENT

- Service manual
- Multimeter
- Test lamp
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Determine that a problem actually exists. Owners unfamiliar with cluster operations may believe there is a problem when the indicators are operating correctly.
2. Locate the proper service manual.
3. Turn ignition to ON.
    a. If the cluster lights, perform self-diagnostic tests according to service manual procedures.
    b. If the cluster does not light, check fuses in the system, battery voltage, grounds, and ignition voltage according to service manual procedures. This will usually include disconnecting the cluster circuit board connector and testing voltage to the connector pins.
4. If the cluster tests correctly but one indicator still seems to malfunction, test the system represented by the indicator and sensors in the system.
5. Have your instructor check your work.
6. Put away tools and materials and clean the work area.

JOB SHEET 4

DRIVER INFORMATION SYSTEMS

VIII

OBJECTIVE 13d **Inspect and service audible alarms.**

TOOLS AND EQUIPMENT

- Service manual
- Test lamp
- Jumper wires
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Activate audible alarms and observe their performance.
2. Perform the following:
    a. If the audible alarm and connected courtesy or warning lights both malfunction, test and service the switch or sensor and circuit according to service manual procedures.

    b. If the audible alarm malfunctions but connected courtesy or warning lights function properly, test audio alarm module and circuit, according to service manual procedures.
3. Have your instructor check your work.
4. Put away tools and materials and clean the work area.

JOB SHEET 5

DRIVER INFORMATION SYSTEMS

VIII

OBJECTIVE 13e **Inspect and service voice notification system problems.**

TOOLS AND EQUIPMENT

- Service manual
- Test lamp

PROCEDURE

1. Activate the Voice Notification System and observe its performance.
2. Perform self-diagnostic tests and follow service manual procedures.
3. Perform the following:

If it talks when its not supposed to	If it doesn't talk
a. Mute the electronic monitor.	a. Check the mute switch
b. If it still talks, replace the voice notification system module.	b. Activate the system check. If it talks, power down the system and reset it.
c. If it stops talking, replace the electronic monitor.	c. Check circuit wiring.
	d. If it gives the chime warnings, replace the voice notification system module.
	e. If it still fails to talk, replace the electronic monitor.

4. Have your instructor check your work.
5. Put away tools and materials and clean the work area.

JOB SHEET 6 — DRIVER INFORMATION SYSTEMS

OBJECTIVE 13f

Replace PROM

INTRODUCTION

Many ECM's include small modules that plug into the main control module. These are called programmable read-only memory. PROM units contain the instructions for the specific make and model. When ECM is replaced, the PROM is usually removed and placed in the new ECM.

TOOLS AND EQUIPMENT

- Service manual
- Replacement ECM
- Fender covers
- Basic tools
- Grounding strap

PROCEDURE

1. Locate the proper service manual. Follow service manual instructions, rather than these general guidelines.
2. Place the car in park if it is an automatic; in neutral if it is a standard.
3. Put the parking brake on.
4. Open the hood.
5. Disconnect battery ground cable.
6. Locate the ECM. Ground yourself with a grounding strap.
7. Lift the locking tabs and unplug connectors.
8. Remove the ECM.
9. Remove the access cover, if equipped.
10. Remove the PROM by lifting it straight out.

CAUTION

Do not touch the terminals or printed circuit boards.

11. Note depressions, alignment tabs, locating tabs, etc.
12. Verify that the proper PROM has been used.

13. Replace PROM in proper position.

14. Replace ECM.

15. Plug connectors into the module, making sure locking tabs are properly set.

16. Replace ECM.

17. Reconnect battery ground cable.

18. Unground self.

19. Have your instructor check your work.

20. Put away tools and materials and clean the work area.

PRACTICAL TEST 1

DRIVER INFORMATION SYSTEMS

VIII

JOB SHEET 1

Inspect and service warning lights.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Located all warning lights.	_____	_____
2. Activated and observed all warning lights.	_____	_____
3. Corrected warning light situations and observed warning lights.	_____	_____
4. Consulted service manual and performed all diagnostic tests.	_____	_____
5. Using service manual, made all service repair and replacements.	_____	_____
6. Used proper tools correctly.	_____	_____
7. Performed steps in a timely manner.	_____	_____
8. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
9. Provided satisfactory responses to questions asked.	____	____
10. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Used service or owner's manual to locate all warning lights	4	3	2	1
Activated and observed all warning lights	4	3	2	1
Corrected all warning light situations and observed all warning lights	4	3	2	1
Performed all self-diagnostic tests according to manual	4	3	2	1
Performed all circuit and component tests according to service manual	4	3	2	1
Diagnosed fault and serviced or replaced correctly	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Inspect and service gauges.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Activated gauges and observed their performance.	_____	_____
2. Tested gauge according to service manual.	_____	_____
3. Serviced or replaced gauge according to service manual.	_____	_____
4. Used proper tools correctly.	_____	_____
5. Performed steps in a timely manner.	_____	_____
6. Practiced safety rules throughout procedure.	_____	_____
7. Provided satisfactory responses to questions asked.	_____	_____
8. Put away tools and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Tested according to service manual	4	3	2	1
Made proper diagnosis and serviced or replaced as indicated	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3

DRIVER INFORMATION SYSTEMS

VIII

JOB SHEET 3 — **Test electronic indicators.**

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Determined that a problem actually existed.	_____	_____
2. Performed self-diagnostic tests according to service manual procedures.	_____	_____
3. If the cluster did not light, checked the following according to service manual procedures:		
a. Fuses in the system	_____	_____
b. Battery voltage	_____	_____
c. Grounds	_____	_____
d. Ignition voltage	_____	_____
4. Used proper tools correctly.	_____	_____
5. Performed steps in a timely manner.	_____	_____
6. Practiced safety rules throughout procedure.	_____	_____
7. Provided satisfactory responses to questions asked.	_____	_____

	YES	NO
8. Put away tools and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the performance for evaluation.

Criteria				
Determined that indicators were not functioning properly by consulting manual	4	3	2	1
Performed self-diagnostic tests correctly	4	3	2	1
Made a correct diagnosis and corrected fault	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

DRIVER INFORMATION SYSTEMS

JOB SHEET 4

Inspect and service audible alarms.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Activated audible alarms and observed performance.	_____	_____
2. Noted performance of related courtesy and warning lights.	_____	_____
3. Diagnosed need to test audible alarm unit or switch-related circuitry.	_____	_____
4. Consulted service manual for proper service procedures.	_____	_____
5. Followed service manual instructions and completed test procedures.		
6. Corrected fault according to service manual procedures.	_____	_____
7. Used proper tools correctly.	_____	_____
8. Performed steps in a timely manner.	_____	_____
9. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
10. Provided satisfactory responses to questions asked.	_____	_____
11. Put away tools and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS ____

____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Activated audible alarms and carefully observed warning and courtesy lights	4	3	2	1
Determined and tested proper circuit	4	3	2	1
Followed service manual testing procedures	4	3	2	1
Corrected fault and retested	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 5

DRIVER INFORMATION SYSTEMS

VIII

JOB SHEET 5

Inspect and service voice notification system problems.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Activated the Voice Notification System and observed its performance.	_____	_____
2. Performed self-diagnostic tests and followed service manual procedures.	_____	_____
3. If it talked when it was not supposed to:		
a. Muted the electronic monitor.	_____	_____
b. If it still talked, replaced the voice notification system module.	_____	_____
c. If it stopped talking, replaced the electronic monitor.	_____	_____
4. If it did not talk:		
a. Checked the mute switch.	_____	_____
b. Activated the system check.	_____	_____
c. If it talked, powered down the system and reset it.	_____	_____
d. Checked circuit wiring.	_____	_____
e. If it gave the chime warnings, replaced the voice notification system module.	_____	_____
f. If it still failed to talk, replaced the electronic monitor.	_____	_____

	YES	NO
5. Used proper tools correctly.	____	____
6. Performed steps in a timely manner.	____	____
7. Practiced safety rules throughout procedure.	____	____
8. Provided satisfactory responses to questions asked.	____	____
9. Put away tools and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Activated the Voice Notification System and carefully observed its performance	4	3	2	1
Performed self-diagnostic test and made a correct diagnosis	4	3	2	1
Serviced system according to manual	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 6

DRIVER INFORMATION SYSTEMS

VIII

JOB SHEET 6

Replace PROM.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Located ECM.	_____	_____
2. Unlocked tabs, unplugged connectors and removed ECM.	_____	_____
3. Removed access cover.	_____	_____
4. Removed PROM.	_____	_____
5. Checked for proper position of PROM and compared part numbers on ECM's.	_____	_____
6. Replaced PROM.	_____	_____
7. Replaced ECM.	_____	_____
8. Used proper tools correctly.	_____	_____
9. Performed steps in a timely manner.	_____	_____
10. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
11. Provided satisfactory responses to questions asked.	_____	_____
12. Put away tools and cleaned work area.	_____	_____

EVALUATOR'S COMMENTS ____

____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Located CPU.	4	3	2	1
Opened locking tabs and connectors gently	4	3	2	1
Located and removed PROM	4	3	2	1
Replaced PROM accurately	4	3	2	1
Replaced and reconnected CPU	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

NAME ________________________________ SCORE ________

OBJECTIVE 1

Match terms associated with servicing driver information systems to their definitions. Write the correct letters in the blanks.

______1. Signals whose voltage values are either one of only two options

______2. A unit made of a halogen light and a special liquid between two panes of glass. When current is applied to the glass, the liquid allows light to pass through it; when current is removed, it remains opaque

______3. A unit using a cathode, anode, screen, and electrons to produce a picture

______4 Electronic parts that produce light when charged with electric current

______5. A group of electrical and electronic instruments grouped together for the common function of driver information

______6. Signals whose voltage values vary

______7. A solid-state device for processing electronic signals generated by sensors

a. Amplifier

b. Analog

c. Buffer

d. Cathode ray tube

e. Cluster

f. Control module

g. CPU

h. Digital

i. LCD's

j. LED's

k. VTF

OBJECTIVE 2 **List common components.**

OBJECTIVE 3 **Distinguish among system designs.** Write a "M" in the blank before statements describing mechanical systems, a "Q-E" in the blank before statements describing quartz-electric systems, and a "D" in the blank before statements describing digital systems. More than one answer may be correct.

______1. Activated devices with mechanical transducers, cables, and sensors

______2. Uses dials and swing needles, so appearance and service are similar to mechanical

______3. Provides estimates of measurements

______4. A sensor sends information to a buffer that processes it into information the system can use: integrated circuits in the automobile's ECM use input to determine the direction and amount of magnetic force in the gauge coils

______5. May be in numerical readout or bar graphs

______6. Uses electronic data, and may also use mechanical input, i.e., speedometer cable

______7. Uses a precision quartz crystal oscillator and electronic to improve accuracy

______8. Limited to older models

OBJECTIVE 4 **Select from a list true statements about the operation of gauges.** Write an "X" in front of true statements.

______1. Each gauge is made of a pointer and a coil at right angles to the pointer.

______2. Current is introduced into the coils and a magnetic field is generated around each one.

______3. Controls current or controls resistance in each coil of the magnetic field strength and moves the needle.

______4. Each gauge is made of a pointer and two wire coils at right angles to each other.

______5. Current is introduced into the pointer and it becomes magnetized.

______6. A gauge does not require electric current.

______7. The needle is moved by gears responding to variations in current.

OBJECTIVE 5 **Complete statements about the operation of electronic indicators.**

1. Electronic indicators are always supplied with

   ______________________.

2. When the circuit is grounded, indicators ________________.

3. Sensors and switches come in a variety of ________________

   and ______________________________

4. Indicators can be lit by _________, _________, or _________.

OBJECTIVE 6

Select from a list true statements about audible alarms. Write an "X" in the blank before true statements.

______ 1. Audible alarms sound only when an emergency or potentially dangerous situation exists.

______ 2. The most common uses of audible alarms are to remind drivers to buckle their seat belts, remove their key from the ignition, and turn off their lights.

______ 3. Audible alarms can be used to warn, inform, or remind drivers.

______ 4. A central audible alarm module sounds a tone when a predetermined set of messages are received from sensors and switches.

______ 5. The most common uses of audible alarms are to activate air bags, warn drivers that fuel is low, and tell drivers that engine temperature is dangerously high.

______ 6. The typical audible alarm sounds when a circuit breaker is opened.

______ 7. The typical audible alarm sounds when two or more circuits are completed.

OBJECTIVE 7

Answer questions about voice notification systems.

1. List three types of sensors.

____

____

____

2. What methods are used for storing voice notification messages?

____

____

____

3. What is the recommended procedure when faults exist within the system?

____

____

____

4. What are the steps in sending a signal from the sensors to the voice notification unit?

____

____

____

NOTICE The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.

OBJECTIVE 8	**Diagnose warning light systems.**	SCORE ______
OBJECTIVE 9	**Complete a gauge system troubleshooting chart.**	SCORE ______
OBJECTIVE 10	**Diagnose electronic indicator problems.**	SCORE ______
OBJECTIVE 11	**Diagnose audible alarm problems.**	SCORE ______
OBJECTIVE 12	**Diagnose voice notification system problems.**	SCORE ______
OBJECTIVE 13a	**Inspect and service warning lights.**	RATING ______
OBJECTIVE 13b	**Inspect and service gauges.**	RATING ______
OBJECTIVE 13c	**Test electronic indicators.**	RATING ______
OBJECTIVE 13d	**Inspect and service audible alarms.**	RATING ______
OBJECTIVE 13e	**Inspect and service voice notification system problems.**	RATING ______
OBJECTIVE 13f	**Replace PROM.**	RATING ______

WRITTEN TEST ANSWERS

DRIVER INFORMATION SYSTEMS

VIII

OBJECTIVE 1

1. h
2. i
3. k
4. j
5. e
6. b
7. c

OBJECTIVE 2

Speedometer
Tachometer
Fuel Gauge
Odometer/Trip Odometer
Audible Alarm Module
Voice Notification Module and Monitoring Unit
Indicator Telltales
Warning lights and indicators
Sensors, amplifiers, and buffers
ECM

OBJECTIVE 3

1. M
2. Q-E
3. M or Q-E
4. Q-E
5. D
6. D or Q-E
7. Q-E
8. M

OBJECTIVE 4

2, 3, 4

OBJECTIVE 5

1. current
2. light
3. types
   functions
4. LED's
   LCD's
   VTF's

OBJECTIVE 6 2, 3, 4, 7

OBJECTIVE 7

1. Any three of the following:

    - Sensors that detect a failure and send voltage to the logic unit when failure occurs
    - Temperature-sensitive resistors that notify the logic unit when resistance is high.
    - Sensors that monitor charging-system voltage
    - Sensors that are open switches.
    - Specialized sensors that monitor temperature, light, or speed used in the coolant system, speedometer, and ignition system.

2. The voice notification may be a series of pre-recorded messages or a series of pre-recorded vocal sounds that may be put together by the logic unit to simulate speech.

3. Voice notification systems may be adjusted and muted, but if a fault exists within the unit itself, the system should be replaced rather than repaired.

4. When sensors send predetermined information to the automobile's logic center, voltage is sent to the audible alarm module and an alarm is sounded. At the same time, the radio may be interrupted. Finally, the voice notification is sounded.

OBJECTIVE 8 Refer to Assignment Sheet 1.

OBJECTIVE 9 Refer to Assignment Sheet 2.

OBJECTIVE 10 Refer to Assignment Sheet 3.

OBJECTIVE 11 Refer to Assignment Sheet 4.

OBJECTIVE 12 Refer to Assignment Sheet 5.

OBJECTIVE 13 Refer to Practical Tests for Job Sheets 1-6.

OBJECTIVE SHEET

MISCELLANEOUS ELECTRICAL COMPONENTS

IX

INTRODUCTION

It has been said that our personalities are reflected in our cars. The style, color, and design reflect our tastes. In the same way, our stereo system, security alarms, and other electrical components tailor our cars to our needs and desires. Servicing these units is somewhat different from servicing others in that these systems are sometimes "after market," meaning they were not designed and installed at the factory, but were added later. Servicing these systems requires a thorough knowledge of electrical circuitry and a basic understanding of the system.

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the circuits and service, and repair entertainment, cruise control, clock, and security systems. The student will demonstrate these competencies by completing assignments sheets, job sheets, practical tests and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Define terms associated with servicing miscellaneous electrical components.
2. List components of entertainment circuits.
3. Select from a list components of clock circuits.
4. Complete statements about cruise control circuits.
5. Select from a list true statements about cruise control designs.
6. List components of security systems.
7. Discuss security system designs.
8. Diagnose entertainment circuit problems. (Assignment Sheet 1).
9. Diagnose clock circuit problems. (Assignment Sheet 2).
10. Diagnose cruise control problems. (Assignment Sheet 3).
11. Diagnose security system problems. (Assignment Sheet 4).

12. Demonstrate the ability to:

    a. Inspect and replace speakers. (Job Sheet 1)

    b. Inspect and replace power antenna. (Job Sheet 2)

    c. Inspect and repair cruise control non-electrical components. (Job Sheet 3)

    d. Inspect and repair cruise control electrical components. (Job Sheet 4)

PREPARATION

- Review unit and plan presentation.
- Study the specific objectives to determine those you will cover in your presentation. Decide also which objectives should be taught to which students.
- Determine the scope and sequence of objectives that you add. Design and develop support materials, including evaluation techniques, for additional objectives.
- Review teaching suggestions and plan classroom activities.
- Determine how you will schedule time for students to demonstrate competence in the required procedures.
- Order materials to supplement unit.
- Invite a stereo customizer or sales representative to discuss system components, trends, common problems, and servicing.
- Invite a repair specialist with training in alarm system installation and servicing to discuss alarm systems.

NOTE: Supply guest speakers with the Objective Sheet, Information Sheet, and any other components you want them to cover.

DELIVERY

Objective 1 Define terms associated with servicing miscellaneous electrical components.

- Review these and other vocabulary words.
- Add vocabulary words to the final test, if necessary.

Objective 2 List components of entertainment circuits.

- Compare older systems to more recent systems that separate the radio head into two or more components.
- Compare radio sizes and shapes. Discuss the convenience of standard radio sizes and trends away from standard sizes among some auto makers.

- Discuss the variety of components available.
- Have students complete Assignment Sheet 1 and Job Sheets 1 and 2.

Objective 3 Select from a list components of clock circuits.

- Stress that clocks themselves rarely fail. Clock problems usually indicate circuit problems.
- Have students check schematics for other systems connected in circuit with clocks.
- Have students complete Assignment Sheet 2.

Objective 4 Complete statements about cruise control circuits.
Objective 5 Select from a list true statements about cruise control designs.

- Compare cruise control systems. Note similarities and differences, especially in switches and sensor locations.
- Have students determine what systems are connected in circuit and how cruise control problems might affect those systems.
- Have students check after-market cruise control systems. Have them check how they are installed and compare their operation to factory systems.
- Have students complete Assignment Sheet 3 and Job Sheets 3 and 4.

Objective 6 List components of security systems.
Objective 7 Discuss security system designs.

- Have students compare security systems.
- Have students check after-market security systems.
- Have students discuss whether security systems actually deter thefts.

- Stress that improper test or service procedures may result in extensive electronic circuit damage.

- Have students complete Assignment Sheet 4.

APPLICATION

Objective 8 Diagnose entertainment circuit problems. (Assignment Sheet 1)
Objective 9 Diagnose clock circuit problems. (Assignment Sheet 2)
Objective 10 Diagnose cruise control problems. (Assignment Sheet 3)
Objective 11 Diagnose security system problems. (Assignment Sheet 4)
Objective 12 Demonstrate an ability to:

- a. **Inspect and replace speakers.** (Job Sheet 1)
- b. **Inspect and replace power antenna.** (Job Sheet 2)
- c. **Inspect and repair cruise control non-electrical components.** (Job Sheet 3)
- d. **Inspect and repair cruise control electrical components.** (Job Sheet 4)

- Have students compare troubleshooting and test procedures among a variety of makes and models.

- Stress that a logical series of tests following the circuit will pinpoint the fault.

- Explain to students that these units are different than other systems that have been discussed in that these units are often installed and serviced by the owner. Unfortunately, the owners often do not understand the circuitry. As one mechanic explained, "when they say 'he's real handy that way' that's a real tip off. You know that whatever he did isn't working."

EVALUATION

Pretest

- Pretest qualifying students.

- Determine individual requirements from pretest results.

- Counsel students individually on pretest results and study requirements.

- Modify materials in unit or create supplementary materials for individual students as required.

Practical test

- Explain to students that they will be asked to demonstrate procedures on the job sheets to complete the practical test.
- Describe the rating scale used on the practical test.
- Reteach and retest as necessary.

Written test

- Explain to students that they will be asked to demonstrate on the written test actions listed in the specific objectives.
- Give written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate students on assignment sheet activities if not previously done.
- Reteach and retest if necessary.
- Complete appropriate section of competency profiles.
- Review individual and group performance in order to evaluate teaching methods. Adjust scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Publications

- *Automotive Electronics and Electrical Equipment*, (10th ed). William H. Crouse's text and workbook, with Instructor's Planning Guide offers fundamental, current information on all aspects of the field. Order Numbers: Text, 014895-3; Workbook, 014896-1; and Instructor's Guide, 014897-X. Available from McGraw/Hill, phone 1-800-334-7344.
- *Automotive Chassis Electronic Systems*. 1990, Ken Layne, covers the operation and servicing of control systems, system by system. Includes chapters on antilock braking systems; electronic cruise control; electronic suspension, steering and transmission control system.

- *Electrical Component Locator.* Offers quick-step procedures fast, accurate location for hard-to-find components for all domestic cars, light trucks, and vans. Available from Mitchell International, phone 1-800-854-7030.

Media

- *Finding the Problem: Troubleshooting On-Board Computer Systems.* Four-part VHS, 40 min, or Filmstrips with Teacher's Guide. Shows "Basic Checking Procedures," "Introduction to Diagnosing a Computer System Malfunction," "Troubleshooting Sensors," and "Troubleshooting Computer System Controls." Order No. 31322-127, available from Vocational Media Association, 1-800-431-1242.

Computer Software

- *Automotive Electronics.* Computerized lessons covering general automotive electronics, General Motors Computer Command Control — C-3 and Input/Output. Three disks for Apple, 48K. Order No. 098-687, available from Career Aids Division, Opportunities for Learning, Inc., 20417 Nordhoff St. Dept IN5, Chatsworth, CA 91311, phone (818) 341-2535.

UNIT REFERENCES

- *1988 Celebrity Electrical Diagnosis, Service Manual Supplement.* General Motors, n.d.
- *1989 Prelude Service Manual.* Honda Motor Co., Ltd., 1988.
- *1990 Electrical Diagrams and Diagnosis Manual.* General Motors, 1989.
- *Body Electronics.* Chrysler Motors, n.d.
- *Electronic Instrumentation - Buick.* General Motors, 1985.
- *Electrical Service and Repair Domestic Cars, 1987 Supplement.* San Diego, California: Mitchell International, Inc., 1987.

PRETEST ANSWERS

MISCELLANEOUS ELECTRICAL COMPONENTS IX

EVALUATOR NOTE:

Use the following answer key to check student answers to pretest questions. To determine the student's individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and written pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Objective	Question
1	1-2
2	3-4
3	5
4	6-9
5	10-12
6	13
7	14-15
8	16-17
9	18-21
10	22
11	23-24
12	25-34

ANSWER KEY

1. c
2. a
3. c
4. a
5. b
6. c
7. a
8. a
9. b
10. a
11. c
12. a
13. b
14. c
15. a
16. b
17. a
18. b
19. c
20. b
21. c
22. c
23. a
24. c
25. a
26. b
27. c
28. a
29. a
30. a
31. b
32. b
33. a
34. b

PRETEST

MISCELLANEOUS ELECTRICAL COMPONENTS IX

NAME ______________________ SCORE ______

DIRECTIONS Read the following questions. Then write the letter that best answers the question in the blank before the statement.

______1. After-market means ___

a. systems that have been used before
b. equipment sold after cars no longer use that equipment
c. components sold separately from the automobile and added to it

______2. A servo is a ___.

a. system in which input and output are compared to determine the desired control
b. small motor used to provide power to electronic devices
c. electronic sensor that monitors motor output to determine electronic control

______3. The radio, radio/cassette player, CD player, etc. in a car's entertainment system is called the ___.

a. sound system
b. system focus
c. system control head

______4. Other components in the entertainment system include ___.

a. amplifiers, speakers, antenna, wiring and connectors, a fuse block, and ignition switch
b. antenna, speakers, amplifiers, wiring, and instrument cluster connections
c. antenna, speakers, and amplifiers only

______5. The clock circuit includes ___.

a. the radio, a readout module, and connections to the on-board computer
b. a clock, fuse block, and wiring
c. a clock, wiring, and the battery

______6. The sensor receiving input used to determine vehicle speed is called the ___.

a. SSU
b. SVS
c. VSS

______7. Input for determining speed is sent to a ___.

a. control or servo unit
b. ECM
c. rheostat

______8. When cruise control is activated, the speed sensor input is compared to ___.

a. input from the cruise control switch
b. preset information in the ECM
c. current speedometer settings

______9. Throttle speed is controlled when cruise control is used by ___.

a. electronic circuitry controlling ignition
b. increasing or venting vacuum pressure on a diaphragm connected to throttle linkages
c. increasing or decreasing the amount of current flowing through cruise control brushes to the cruise control shaft

_____10. Cruise control system designs ___

a. vary among makes and models
b. are very standard and basic
c. can be divided into four basic categories

_____11. Speed sensors are found ___

a. on the transaxle
b. connected to the speedometer cable or cable head
c. either A or B

_____12. Speed sensors may "count" ___

a. magnetic or light pulses
b. ripples in electric current
c. vibrations in the speedometer circuit

_____13. Security system components include ___

a. circuit boards located in strategic locations throughout the car, wiring, a horn, and lights
b. switches, the horn, lights, a controller, an alarm relay, a starter interrupt relay, and a disarm relay
c. keys, lock relays, disarm control module, and alarm

_____14. Security systems become armed when the ___

a. security system switch is closed
b. engine is turned off
c. car is parked, the key is removed from the ignition, and the doors are locked

_____15. Typically, attempted theft causes the security system circuit to ___

a. become grounded and thereby complete
b. send current to a variety of switches
c. compare current sensor measurements to those in ECM memory

_____16. The car is ___.

a. a perfect acoustical setting for stereo sound
b. the worst possible acoustical setting for stereo sound
c. impossible to evaluate acoustically

_____17. Diagnosing entertainment system problems is difficult because ___.

a. the setting is bad, systems vary and may be complicated, and systems may be installed by people who don't know how
b. there are so many components in the system
c. testing procedures are so different than those used with other systems

_____18. When a customer complains about radio problems, you should always ___.

a. remove the radio and test it separately
b. verify that the owner knows how to operate the radio
c. refer him or her to a radio specialist

_____19. A clock is connected in circuit with other loads that ___.

a. have digital readouts
b. use the clock to calculate speed, etc.
c. always receive voltage

_____20. Removing the battery ___.

a. may cause the clock to run fast or slow
b. may erase the clock's memory
c. will not affect the clock

_____21. Clock circuit problems are ___.

a. always caused by the clock
b. usually caused by the clock
c. rarely caused by the clock

_____22. Cruise control service procedures ___.

a. are the same on any car
b. require sophisticated electronic equipment
c. vary widely among makes and models

_____23. To service a security system, you must consider ___.

a. what systems are connected in circuit
b. how old the car is
c. whether the car is foreign or domestic

_____24. Activated alarm systems ___.

a. activate voice notification systems
b. flash hazard lights
c. sound the horn and flash the headlights

_____25. Ground screws can affect sound system circuits if they are ___.

a. painted
b. too long
c. bent

_____26. Sound system voltage should be ___.

a. less than battery voltage
b. equal to battery voltage
c. greater than battery voltage

_____27. Internal static is ___.

a. picked up by the antenna
b. caused by the antenna
c. not picked up by the antenna

_____28. Internal noise can be caused by ___.

a. spark plug wires, defective distributor cap and rotor, or air conditioning grounds
b. power seats and windows or courtesy lights
c. a discharged battery or defective alternator

_____29. If an analog ohmmeter is connected across speaker terminals on a good speaker, the speaker will ___.

a. pop
b. remain silent
c. buzz

_____30. To test an antenna ___.

a. disconnect the radio from the antenna and plug in a known good antenna
b. measure resistance in the antenna plug
c. disconnect the radio from the antenna and plug the antenna in to a known good radio

_____31. If reception with a power antenna is weak or fading, the ___.

a. wiring is shorted
b. drive housing should be cleaned
c. antenna needs to be grounded

_____32. The cruise control actuator should be checked by applying ___.

a. voltage
b. vacuum
c. voltage and vacuum

_____33. Cruise control electronic components that should be tested are the ___.

a. servo, switches, and sensors
b. servo, sensors, and resistors
c. sensors, switches, and resistors

_____34. If power locks and windows fail to operate on the driver's side door at the same time the security system malfunctions ___.

a. the power locks and windows should be repaired before testing the security system
b. the fault is probably in wiring or switches shared by all circuits
c. the security system is probably causing the other problems and should be thoroughly tested

INFORMATION SHEET

MISCELLANEOUS ELECTRICAL COMPONENTS *IX*

OBJECTIVE 1

Define terms associated with servicing miscellaneous electrical components.

- **After-market** — Components sold separately from the automobile and added to it
- **Servo** — A system in which input and output are compared to determine the desired control

OBJECTIVE 2

List components of entertainment circuits.

- Entertainment system control head
    - Radio
    - Cassette player
    - CD player/changer
    - Equalizer
    - Clock
- Amplifier
- Speaker
- Antenna
- Wiring and connectors
- Fuse block
- Ignition switch

OBJECTIVE 3

Select from a list components of clock circuits.

- Clock

- Fuse block

  NOTE: Clocks are usually connected in circuit with another system that always receives current, usually the cigarette lighter or courtesy light system. In most recent-model cars the clock is part of the radio head.

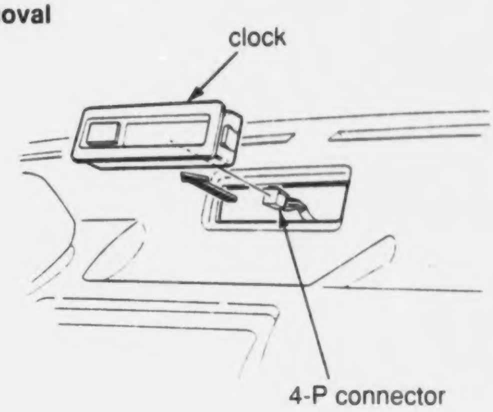
- Clock memory (if digital)
- Wiring and connectors

Pry out the clock from the dashboard, then disconnect the 4-P connector from the clock.

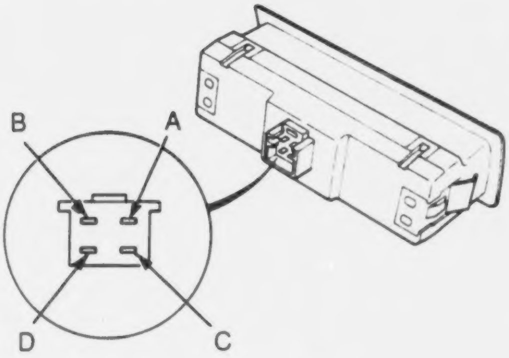
CAUTION

Be careful not to damage the clock and dashboard.

Removal



Terminals



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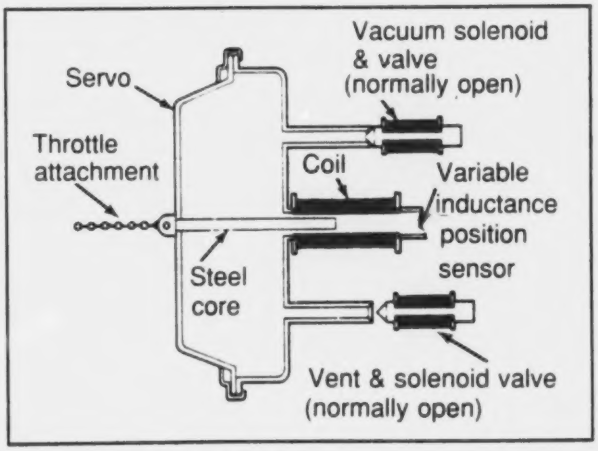
OBJECTIVE 4

Complete statements about cruise control circuits.

- The Vehicle Speed Sensor (VSS) receives input (usually magnetic pulses) indicating the speed of the vehicle and sends this information to a control or servo unit.

- The control or servo unit receives information from the VSS and compares it to input from the cruise control switch indicating the speed desired by the driver.

- The control or servo unit sends current to solenoids that either increase or vent vacuum pressure on a diaphragm connected to throttle linkages.


Vacuum solenoid & valve (normally open)
Servo
Throttle attachment
Coil
Variable inductance position sensor
Steel core
Vent & solenoid valve (normally open)

Used with permission of Mitchell International.

- The linkages, moved by the diaphragm, move the throttle and speed is increased or decreased.

OBJECTIVE 5

Select from a list true statements about cruise control designs.

- Designs vary among makes and models. For details about cruise control design, consult a service manual.

- One major design difference is the location of the VSS.

  - VSS may be located on the transaxle. A magnet rotates with the transaxle and the VSS picks up the magnetic pulses as it passes. These voltage pulses are used to calculate the speed of the transaxle shaft rotation and then the speed of the car.

- The vehicle speed may also be determined by attaching a reflective blade to the speedometer cable. The blade spins as the cable turns. Light from a LED aimed at the blade is sensed by an optic head and the light pulses are used to calculate vehicle speed.

OBJECTIVE 6 **List components of security systems.**

- Controller
- Switches
- Alarm relay
- Starter interrupt relay
- Horn
- Exterior lights
- Disarm relay

NOTE: Security systems are connected in circuit with a variety of systems including door lock, trunk, or hatchback release switches, courtesy lights, and keyless entry systems.

OBJECTIVE 7 **Discuss security system designs.**

- Security system designs vary among makes and models. For details about any security system design, consult a service manual.

WARNING: Do not attempt testing or servicing a security system without following manual procedures.

- Two basic types are active, that require arming by the driver, and passive, which arm themselves.
- Security systems become armed when the car is parked, the key is removed from the ignition, and the doors are locked.

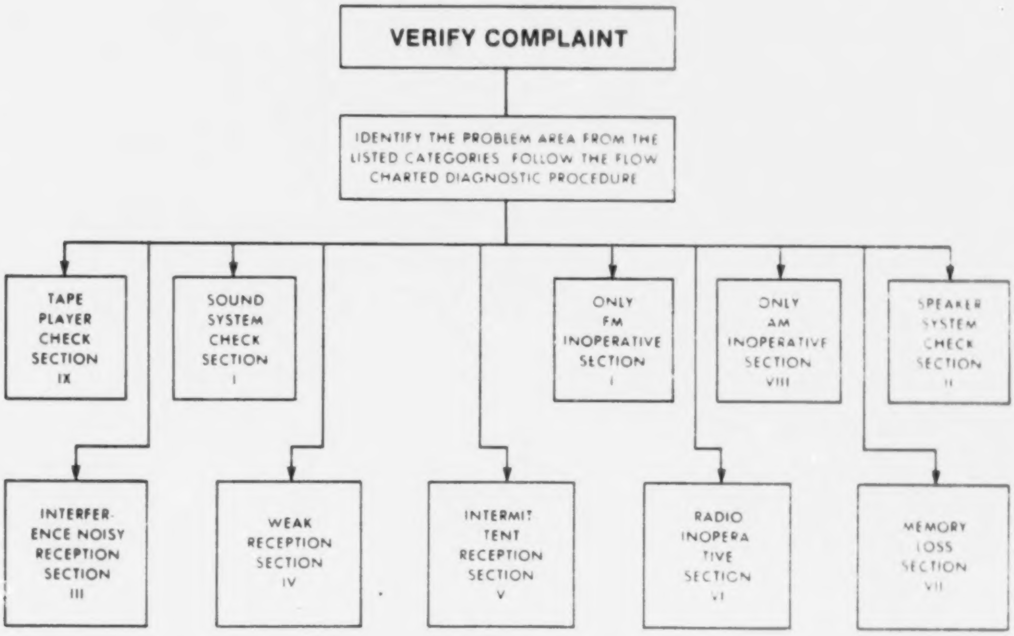
- Sensors and switches in strategic locations throughout the car activate the system when tripped. Typically, attempted theft causes the circuit to become grounded and thereby complete. The completed circuit sends current to an alarm system that honks the horn and flashes lights.

MORE THAN SWITCHES

If you think security systems are activated by just another wire connected to the doorjamb light switches, look out! Security systems become more sophisticated daily, and while all systems do still use common door and lock switches, technology offers other sensors as well. For instance, many systems now use "shock" sensors that react to unusual bumps or noises. The Microvision Security System uses doppler radar to sense movement within the automobile.

- Many security systems now include a starter disable. These units prevent the starter from working if the system is tripped or if certain starting procedures (using a keyless entry or ignition key for example) are not used.

RADIO DIAGNOSIS SECTION


VERIFY COMPLAINT
IDENTIFY THE PROBLEM AREA FROM THE LISTED CATEGORIES. FOLLOW THE FLOW CHARTED DIAGNOSTIC PROCEDURE
TAPE PLAYER CHECK SECTION IX
SOUND SYSTEM CHECK SECTION I
ONLY FM INOPERATIVE SECTION I
ONLY AM INOPERATIVE SECTION VIII
SPEAKER SYSTEM CHECK SECTION II
INTERFERENCE NOISY RECEPTION SECTION III
WEAK RECEPTION SECTION IV
INTERMITTENT RECEPTION SECTION V
RADIO INOPERATIVE SECTION VI
MEMORY LOSS SECTION VII

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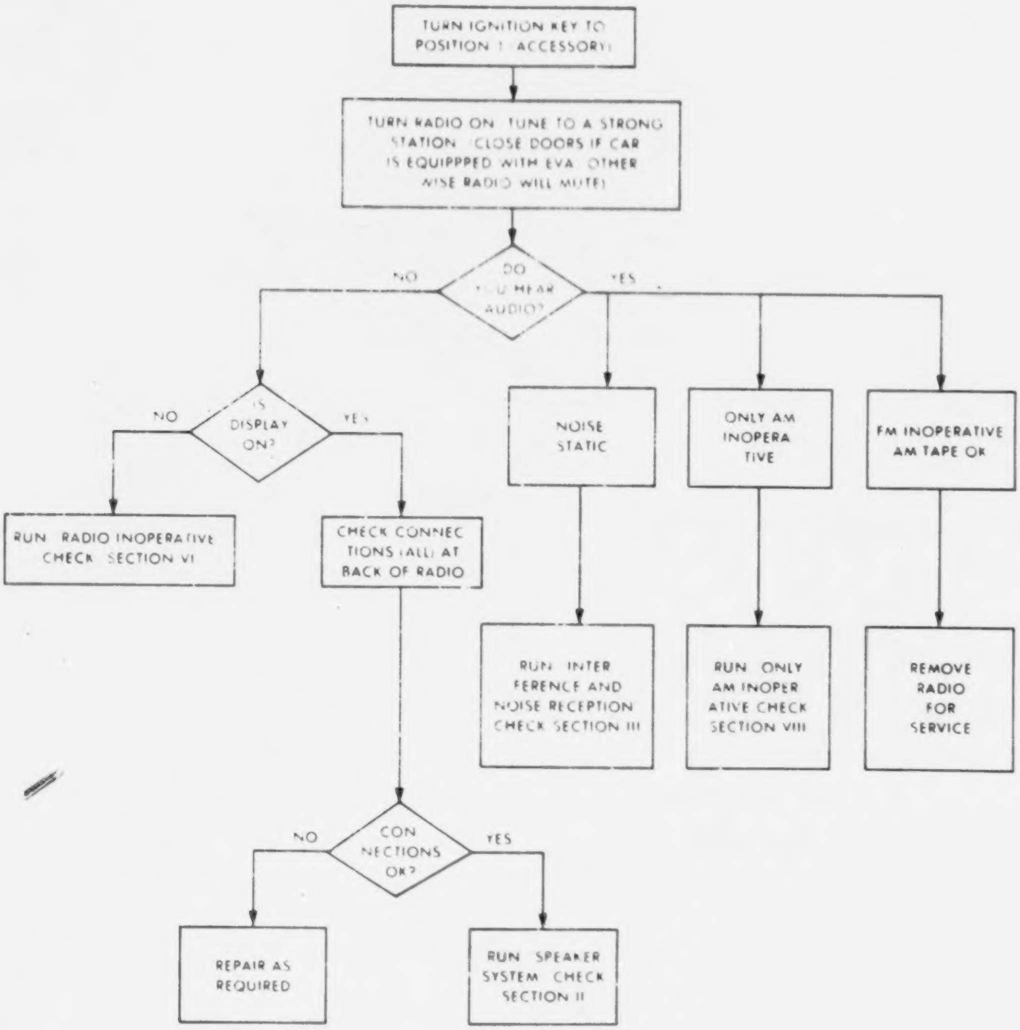
SOUND SYSTEM CHECK SECTION I


TURN IGNITION KEY TO POSITION 1 (ACCESSORY)
TURN RADIO ON. TUNE TO A STRONG STATION. (CLOSE DOORS IF CAR IS EQUIPPPED WITH EVA. OTHERWISE RADIO WILL MUTE)
DO YOU HEAR AUDIO?
NO
YES
IS DISPLAY ON?
NO
YES
RUN "RADIO INOPERATIVE CHECK" SECTION VI
CHECK CONNECTIONS (ALL) AT BACK OF RADIO
NOISE STATIC
ONLY AM INOPERATIVE
FM INOPERATIVE AM TAPE OK
RUN "INTERFERENCE AND NOISE RECEPTION CHECK" SECTION III
RUN "ONLY AM INOPERATIVE CHECK" SECTION VIII
REMOVE RADIO FOR SERVICE
CONNECTIONS OK?
NO
YES
REPAIR AS REQUIRED
RUN "SPEAKER SYSTEM CHECK" SECTION II

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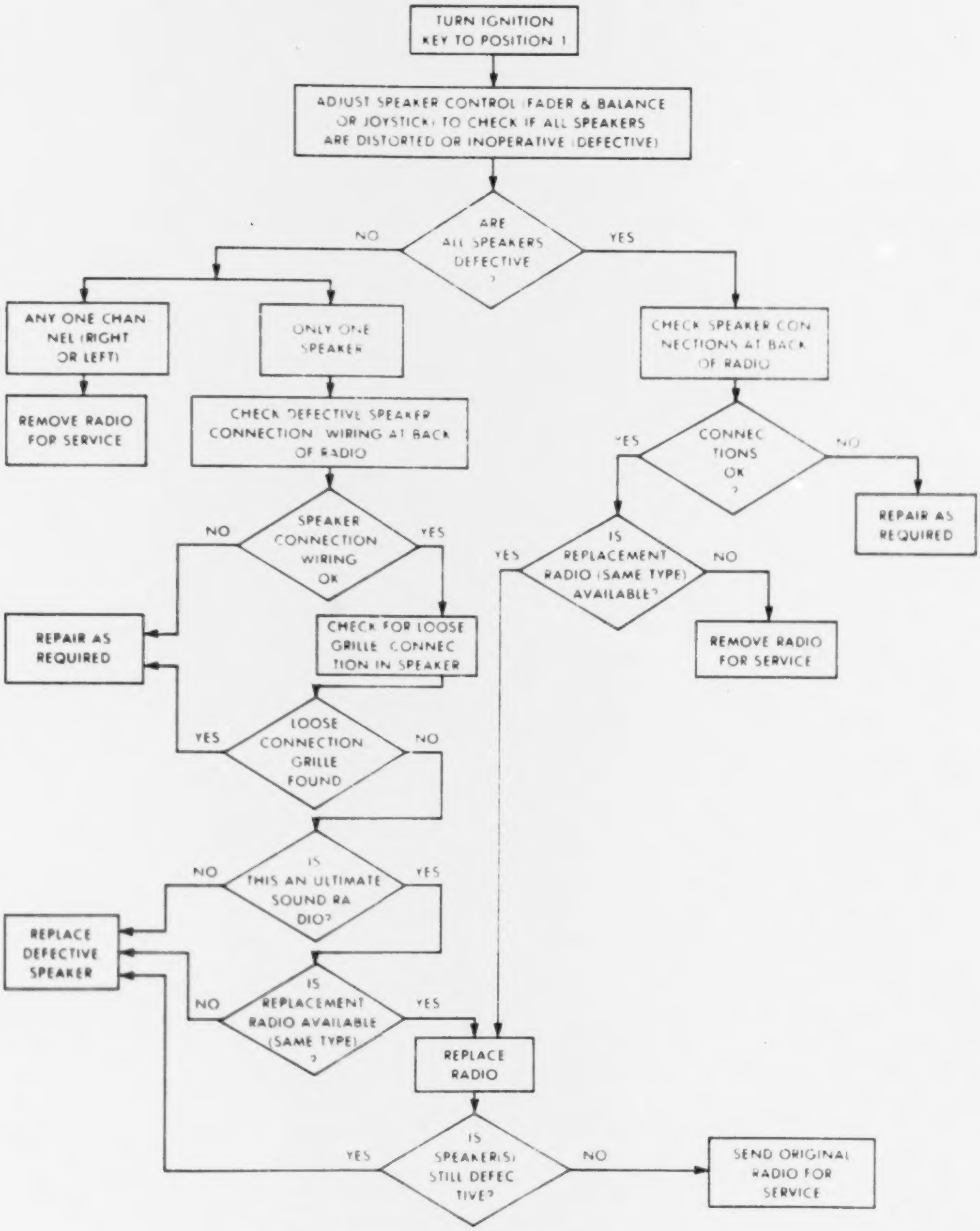
SPEAKER SYSTEM CHECK SECTION II


TURN IGNITION KEY TO POSITION 1
ADJUST SPEAKER CONTROL (FADER & BALANCE OR JOYSTICK) TO CHECK IF ALL SPEAKERS ARE DISTORTED OR INOPERATIVE (DEFECTIVE)
ARE ALL SPEAKERS DEFECTIVE ?
NO
YES
ANY ONE CHANNEL (RIGHT OR LEFT)
ONLY ONE SPEAKER
CHECK SPEAKER CONNECTIONS AT BACK OF RADIO
REMOVE RADIO FOR SERVICE
CHECK DEFECTIVE SPEAKER CONNECTION WIRING AT BACK OF RADIO
YES
CONNECTIONS OK ?
NO
REPAIR AS REQUIRED
NO
SPEAKER CONNECTION WIRING OK
YES
YES
IS REPLACEMENT RADIO (SAME TYPE) AVAILABLE?
NO
REPAIR AS REQUIRED
CHECK FOR LOOSE GRILLE CONNECTION IN SPEAKER
REMOVE RADIO FOR SERVICE
YES
LOOSE CONNECTION GRILLE FOUND
NO
NO
IS THIS AN ULTIMATE SOUND RADIO?
YES
REPLACE DEFECTIVE SPEAKER
NO
IS REPLACEMENT RADIO AVAILABLE (SAME TYPE) ?
YES
REPLACE RADIO
YES
IS SPEAKER(S) STILL DEFECTIVE?
NO
SEND ORIGINAL RADIO FOR SERVICE

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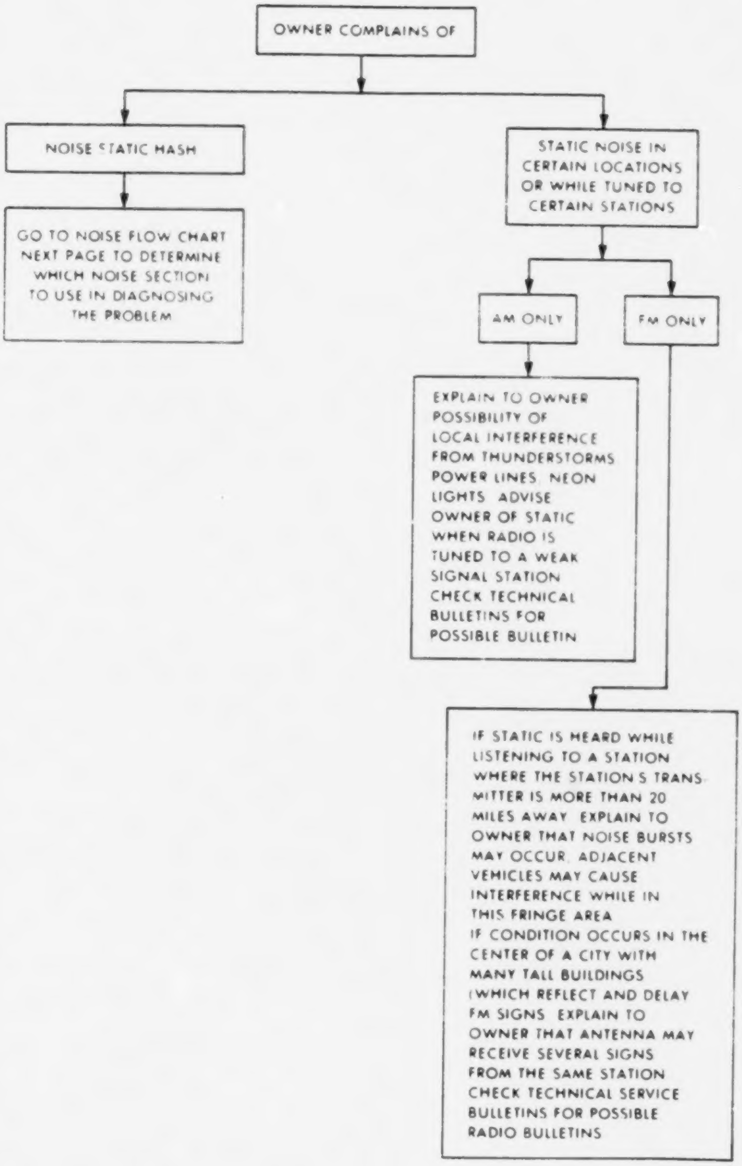
INTERFERENCE AND NOISY RECEPTION CHECK SECTION III


OWNER COMPLAINS OF
NOISE STATIC HASH
GO TO NOISE FLOW CHART NEXT PAGE TO DETERMINE WHICH NOISE SECTION TO USE IN DIAGNOSING THE PROBLEM
STATIC NOISE IN CERTAIN LOCATIONS OR WHILE TUNED TO CERTAIN STATIONS
AM ONLY
FM ONLY
EXPLAIN TO OWNER POSSIBILITY OF LOCAL INTERFERENCE FROM THUNDERSTORMS POWER LINES NEON LIGHTS ADVISE OWNER OF STATIC WHEN RADIO IS TUNED TO A WEAK SIGNAL STATION CHECK TECHNICAL BULLETINS FOR POSSIBLE BULLETIN
IF STATIC IS HEARD WHILE LISTENING TO A STATION WHERE THE STATION S TRANSMITTER IS MORE THAN 20 MILES AWAY EXPLAIN TO OWNER THAT NOISE BURSTS MAY OCCUR. ADJACENT VEHICLES MAY CAUSE INTERFERENCE WHILE IN THIS FRINGE AREA
IF CONDITION OCCURS IN THE CENTER OF A CITY WITH MANY TALL BUILDINGS (WHICH REFLECT AND DELAY FM SIGNS EXPLAIN TO OWNER THAT ANTENNA MAY RECEIVE SEVERAL SIGNS FROM THE SAME STATION CHECK TECHNICAL SERVICE BULLETINS FOR POSSIBLE RADIO BULLETINS

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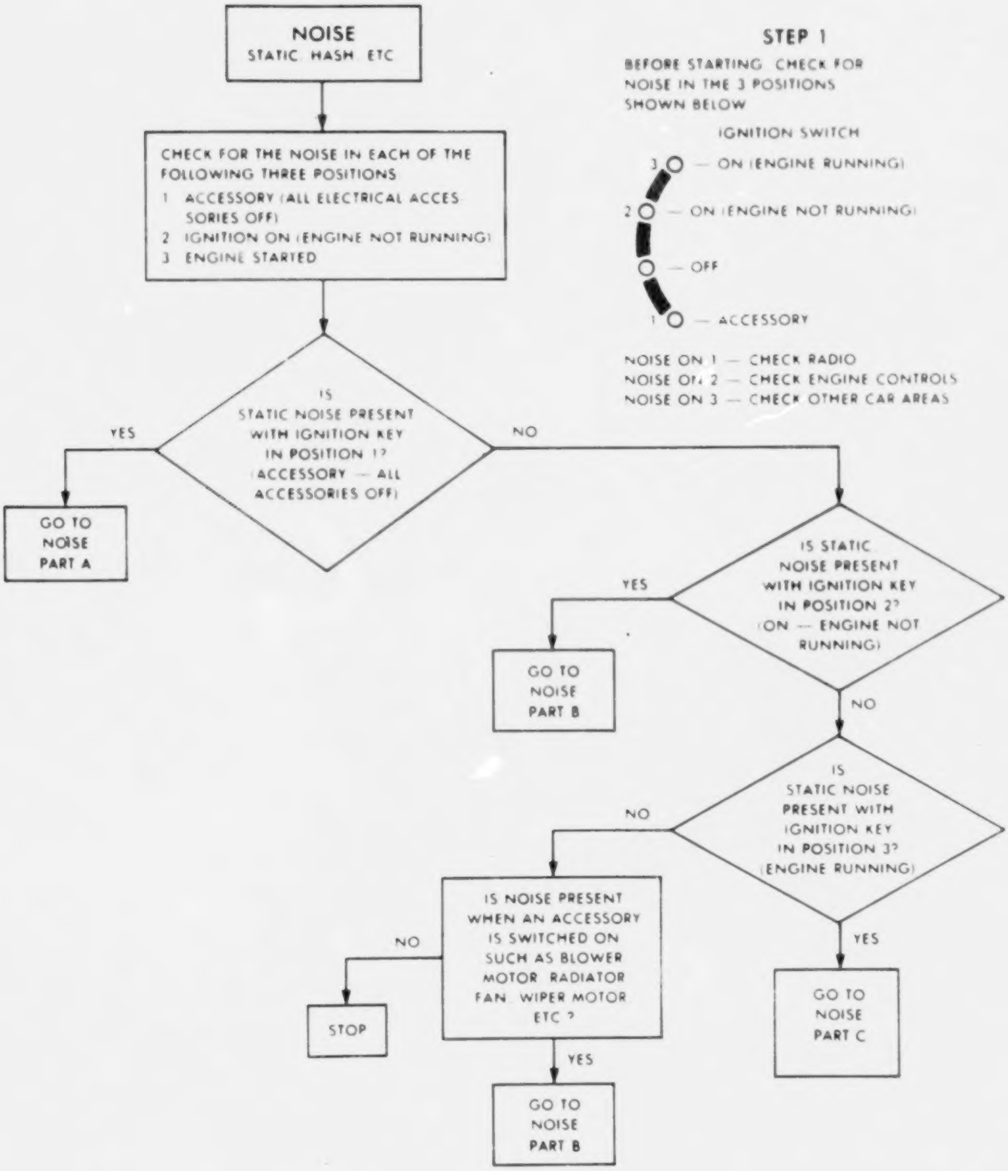
INTERFERENCE/NOISY RECEPTION SECTION III


NOISE
STATIC, HASH, ETC
CHECK FOR THE NOISE IN EACH OF THE FOLLOWING THREE POSITIONS
1 ACCESSORY (ALL ELECTRICAL ACCESSORIES OFF)
2 IGNITION ON (ENGINE NOT RUNNING)
3 ENGINE STARTED
IS STATIC NOISE PRESENT WITH IGNITION KEY IN POSITION 1? (ACCESSORY — ALL ACCESSORIES OFF)
YES
GO TO NOISE PART A
NO
IS STATIC NOISE PRESENT WITH IGNITION KEY IN POSITION 2? (ON — ENGINE NOT RUNNING)
YES
GO TO NOISE PART B
NO
IS STATIC NOISE PRESENT WITH IGNITION KEY IN POSITION 3? (ENGINE RUNNING)
YES
GO TO NOISE PART C
NO
IS NOISE PRESENT WHEN AN ACCESSORY IS SWITCHED ON SUCH AS BLOWER MOTOR, RADIATOR FAN, WIPER MOTOR, ETC.?
NO
STOP
YES
GO TO NOISE PART B
IGNITION SWITCH
3 — ON (ENGINE RUNNING)
2 — ON (ENGINE NOT RUNNING)
— OFF
1 — ACCESSORY

STEP 1

BEFORE STARTING, CHECK FOR NOISE IN THE 3 POSITIONS SHOWN BELOW

NOISE ON 1 — CHECK RADIO
NOISE ON 2 — CHECK ENGINE CONTROLS
NOISE ON 3 — CHECK OTHER CAR AREAS

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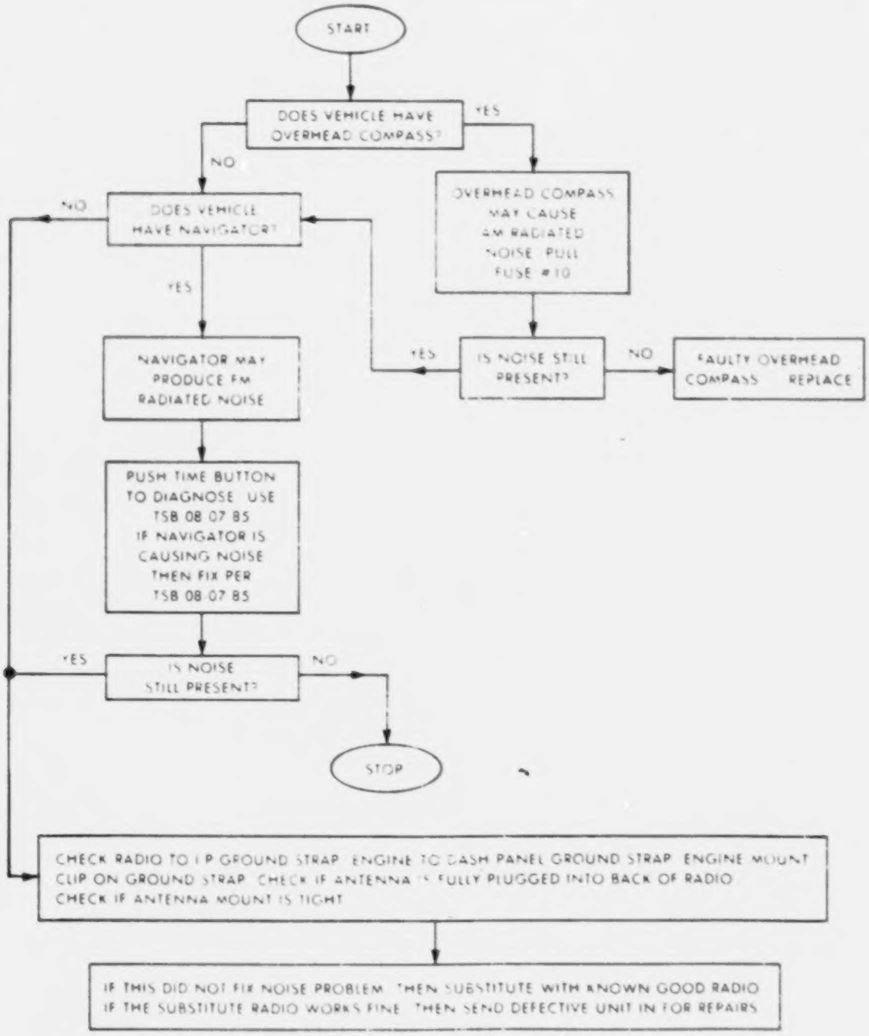
INTERFERENCE/NOISY RECEPTION SECTION III

Noise Part A

This section is for radio noise static with the ignition switch in position 1 — accessory (with all accessories switched off)


START
DOES VEHICLE HAVE OVERHEAD COMPASS?
YES
NO
OVERHEAD COMPASS MAY CAUSE AM RADIATED NOISE. PULL FUSE #10
NO
DOES VEHICLE HAVE NAVIGATOR?
YES
IS NOISE STILL PRESENT?
YES
NO
FAULTY OVERHEAD COMPASS. REPLACE
NAVIGATOR MAY PRODUCE FM RADIATED NOISE
PUSH TIME BUTTON TO DIAGNOSE. USE TSB 08 07 85 IF NAVIGATOR IS CAUSING NOISE THEN FIX PER TSB 08 07 85
YES
IS NOISE STILL PRESENT?
NO
STOP
CHECK RADIO TO I.P. GROUND STRAP. ENGINE TO DASH PANEL GROUND STRAP. ENGINE MOUNT CLIP ON GROUND STRAP. CHECK IF ANTENNA IS FULLY PLUGGED INTO BACK OF RADIO. CHECK IF ANTENNA MOUNT IS TIGHT
IF THIS DID NOT FIX NOISE PROBLEM, THEN SUBSTITUTE WITH KNOWN GOOD RADIO. IF THE SUBSTITUTE RADIO WORKS FINE, THEN SEND DEFECTIVE UNIT IN FOR REPAIRS

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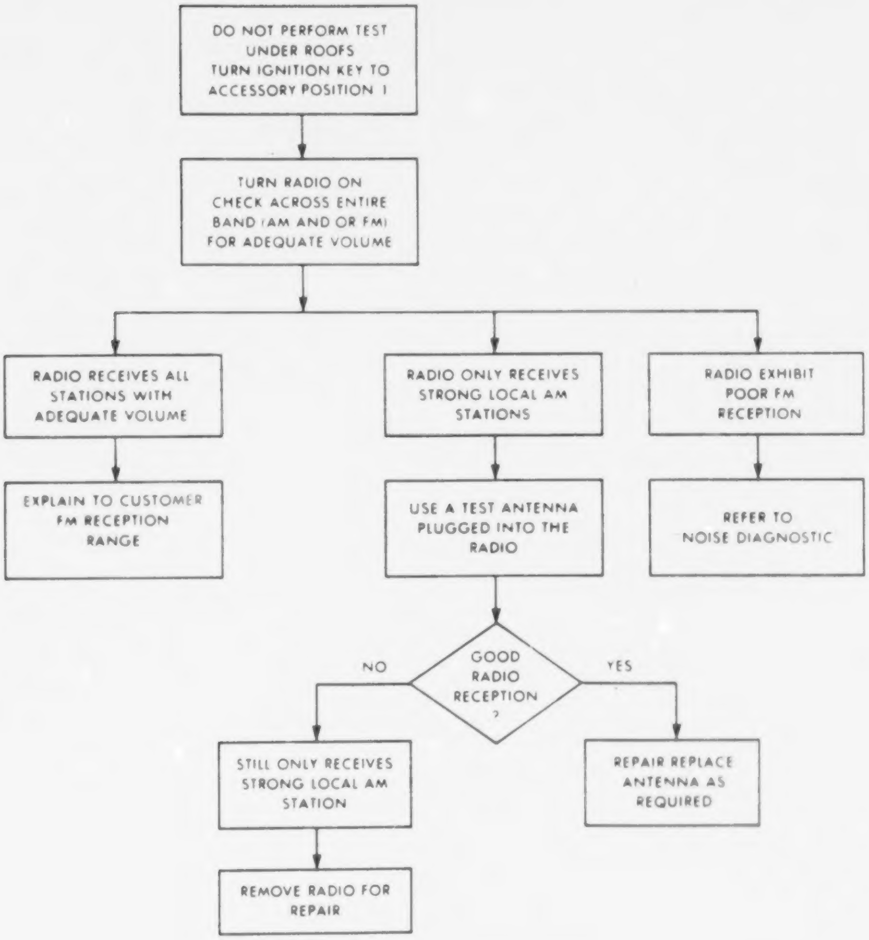
WEAK RADIO SIGNAL CHECK SECTION IV


DO NOT PERFORM TEST UNDER ROOFS TURN IGNITION KEY TO ACCESSORY POSITION 1
TURN RADIO ON CHECK ACROSS ENTIRE BAND (AM AND OR FM) FOR ADEQUATE VOLUME
RADIO RECEIVES ALL STATIONS WITH ADEQUATE VOLUME
RADIO ONLY RECEIVES STRONG LOCAL AM STATIONS
RADIO EXHIBIT POOR FM RECEPTION
EXPLAIN TO CUSTOMER FM RECEPTION RANGE
USE A TEST ANTENNA PLUGGED INTO THE RADIO
REFER TO NOISE DIAGNOSTIC
NO
GOOD RADIO RECEPTION ?
YES
STILL ONLY RECEIVES STRONG LOCAL AM STATION
REPAIR REPLACE ANTENNA AS REQUIRED
REMOVE RADIO FOR REPAIR

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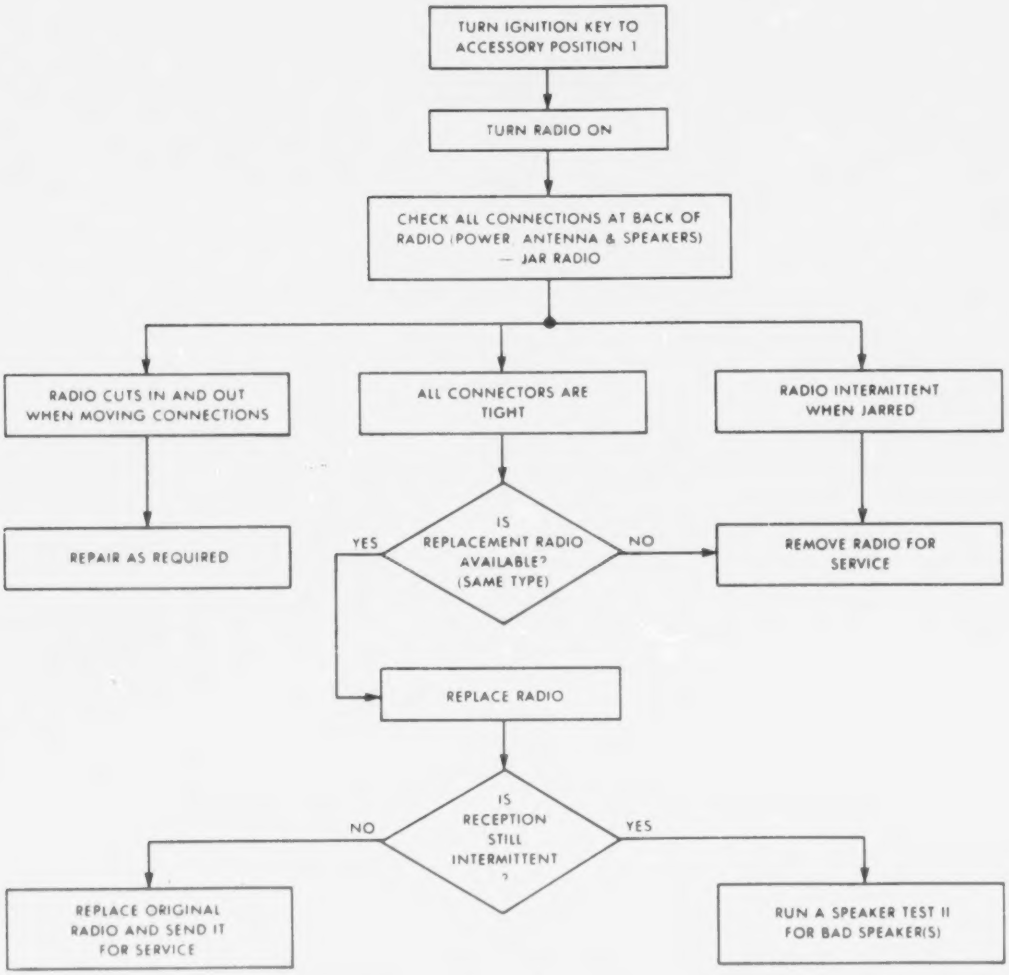
INTERMITTENT RECEPTION CHECK SECTION V


TURN IGNITION KEY TO ACCESSORY POSITION 1
TURN RADIO ON
CHECK ALL CONNECTIONS AT BACK OF RADIO (POWER ANTENNA & SPEAKERS) — JAR RADIO
RADIO CUTS IN AND OUT WHEN MOVING CONNECTIONS
ALL CONNECTORS ARE TIGHT
RADIO INTERMITTENT WHEN JARRED
REPAIR AS REQUIRED
YES
IS REPLACEMENT RADIO AVAILABLE? (SAME TYPE)
NO
REMOVE RADIO FOR SERVICE
REPLACE RADIO
NO
IS RECEPTION STILL INTERMITTENT ?
YES
REPLACE ORIGINAL RADIO AND SEND IT FOR SERVICE
RUN A SPEAKER TEST II FOR BAD SPEAKER(S)

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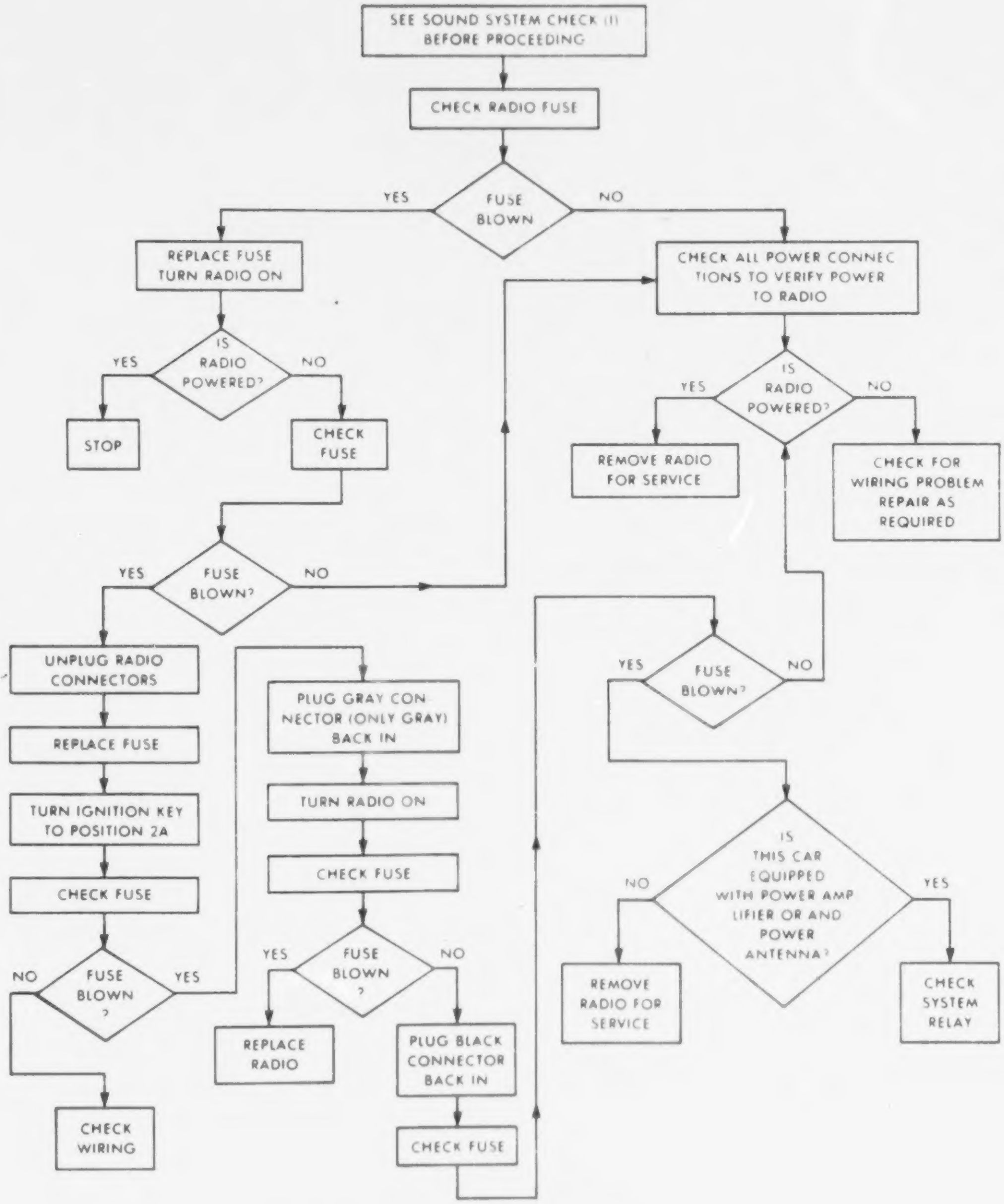
RADIO INOPERATIVE CHECK SECTION VI


SEE SOUND SYSTEM CHECK (I) BEFORE PROCEEDING
CHECK RADIO FUSE
FUSE BLOWN
YES
NO
REPLACE FUSE TURN RADIO ON
CHECK ALL POWER CONNECTIONS TO VERIFY POWER TO RADIO
IS RADIO POWERED?
YES
NO
STOP
CHECK FUSE
IS RADIO POWERED?
YES
NO
REMOVE RADIO FOR SERVICE
CHECK FOR WIRING PROBLEM REPAIR AS REQUIRED
FUSE BLOWN?
YES
NO
UNPLUG RADIO CONNECTORS
REPLACE FUSE
TURN IGNITION KEY TO POSITION 2A
CHECK FUSE
FUSE BLOWN ?
NO
YES
CHECK WIRING
PLUG GRAY CONNECTOR (ONLY GRAY) BACK IN
TURN RADIO ON
CHECK FUSE
FUSE BLOWN ?
YES
NO
REPLACE RADIO
PLUG BLACK CONNECTOR BACK IN
CHECK FUSE
FUSE BLOWN?
YES
NO
IS THIS CAR EQUIPPED WITH POWER AMPLIFIER OR AND POWER ANTENNA?
NO
YES
REMOVE RADIO FOR SERVICE
CHECK SYSTEM RELAY

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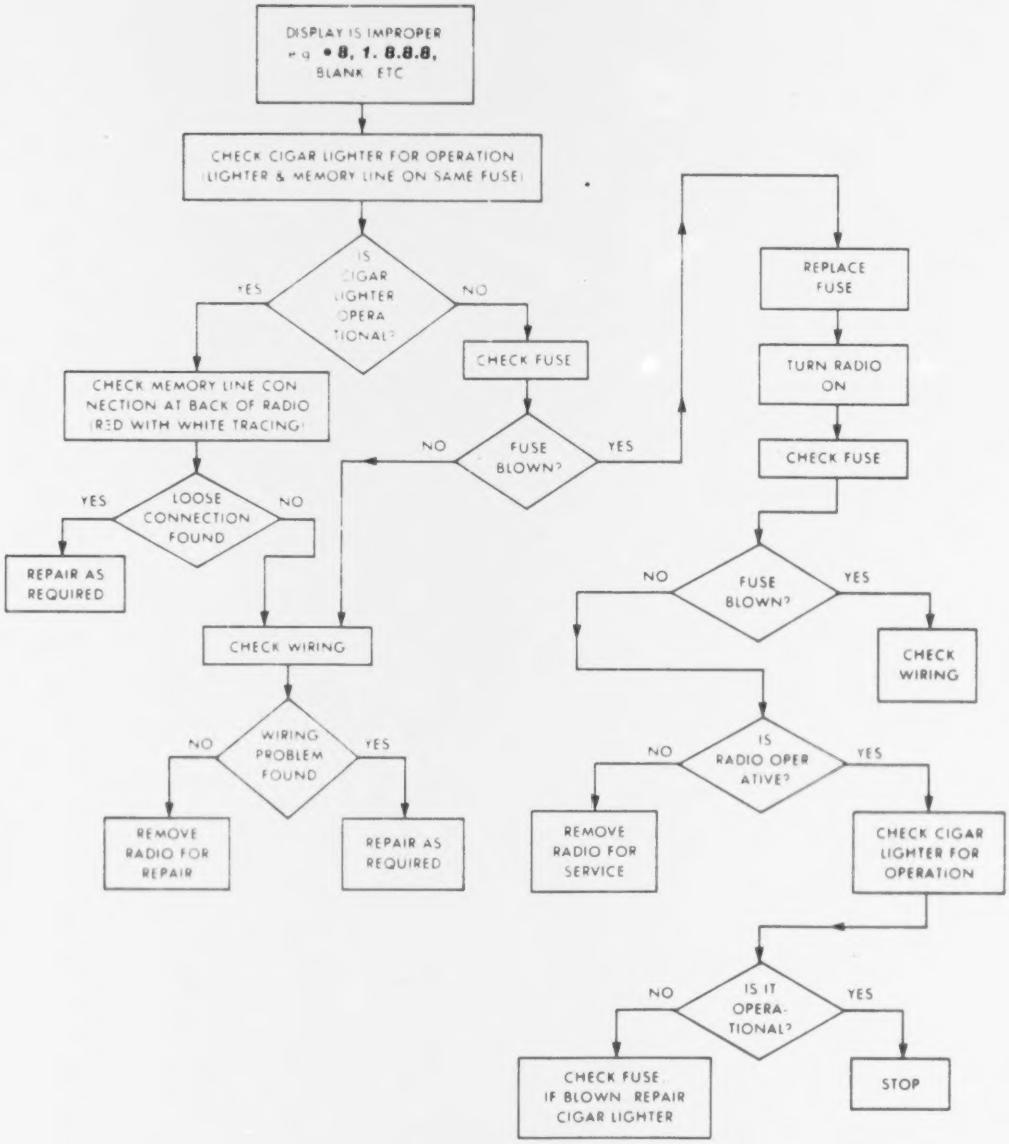
MEMORY LOSS CHECK SECTION VII


DISPLAY IS IMPROPER
e.g. •8, 1. 8.8.8,
BLANK ETC
CHECK CIGAR LIGHTER FOR OPERATION
(LIGHTER & MEMORY LINE ON SAME FUSE)
IS CIGAR LIGHTER OPERATIONAL?
YES
NO
CHECK MEMORY LINE CONNECTION AT BACK OF RADIO (RED WITH WHITE TRACING)
CHECK FUSE
NO
FUSE BLOWN?
YES
YES
LOOSE CONNECTION FOUND
NO
REPAIR AS REQUIRED
CHECK WIRING
NO
WIRING PROBLEM FOUND
YES
REMOVE RADIO FOR REPAIR
REPAIR AS REQUIRED
REPLACE FUSE
TURN RADIO ON
CHECK FUSE
NO
FUSE BLOWN?
YES
CHECK WIRING
NO
IS RADIO OPERATIVE?
YES
REMOVE RADIO FOR SERVICE
CHECK CIGAR LIGHTER FOR OPERATION
NO
IS IT OPERATIONAL?
YES
CHECK FUSE. IF BLOWN REPAIR CIGAR LIGHTER
STOP

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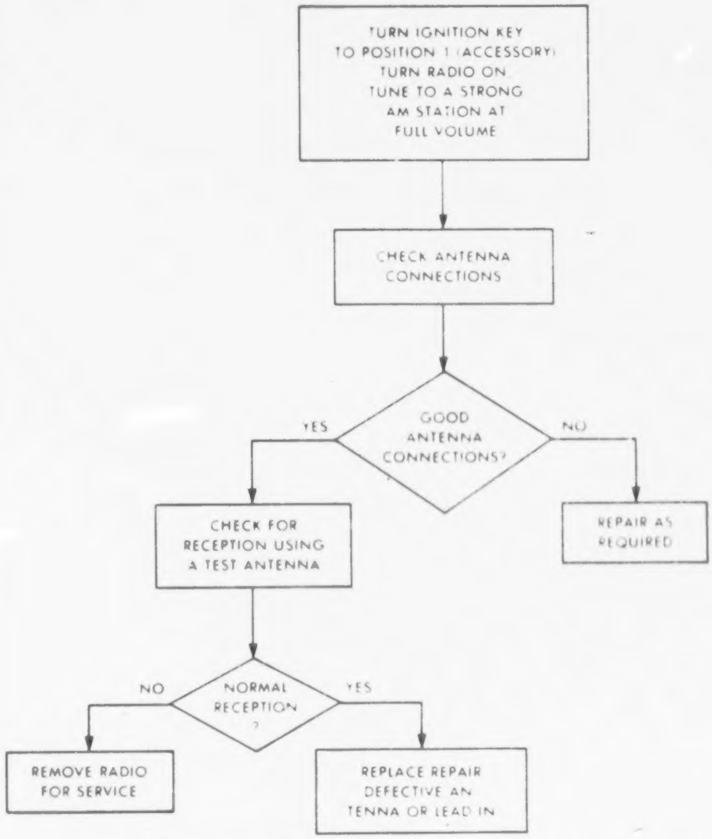
ONLY AM INOPERATIVE CHECK SECTION VIII


TURN IGNITION KEY TO POSITION 1 (ACCESSORY) TURN RADIO ON TUNE TO A STRONG AM STATION AT FULL VOLUME
CHECK ANTENNA CONNECTIONS
GOOD ANTENNA CONNECTIONS?
YES
NO
CHECK FOR RECEPTION USING A TEST ANTENNA
REPAIR AS REQUIRED
NORMAL RECEPTION ?
NO
YES
REMOVE RADIO FOR SERVICE
REPLACE REPAIR DEFECTIVE AN TENNA OR LEAD IN

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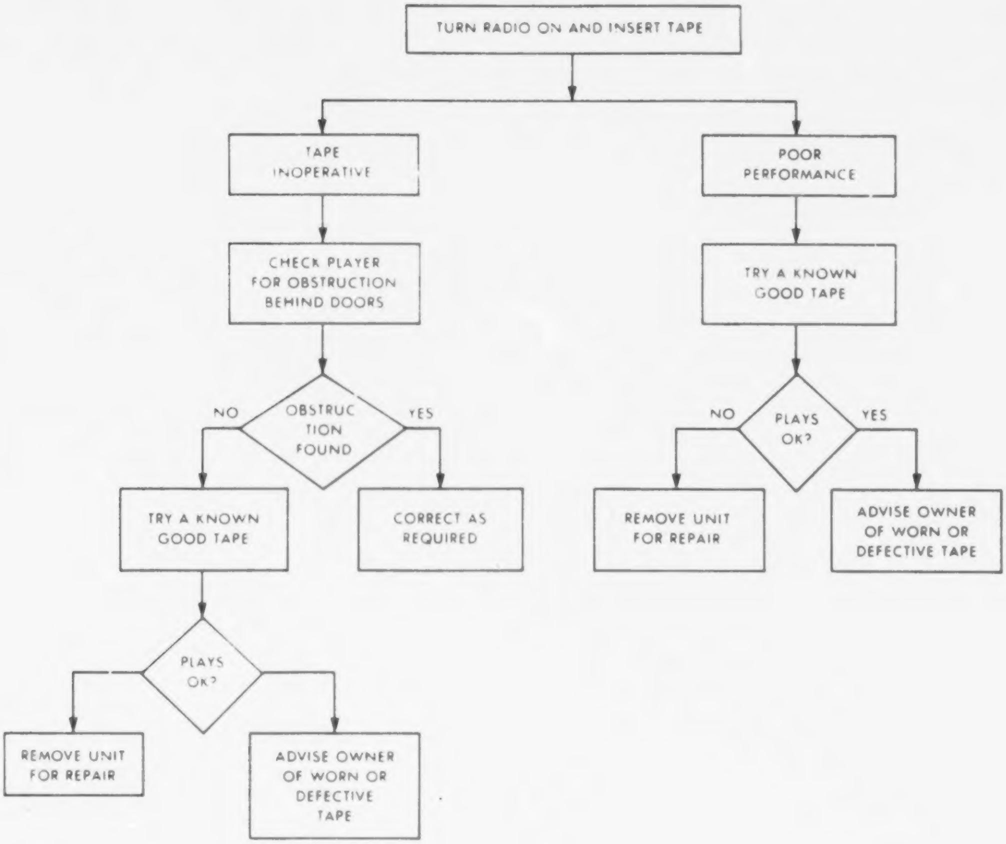
CASSETTE TAPE PLAYER DIAGNOSIS SECTION IX


TURN RADIO ON AND INSERT TAPE
TAPE INOPERATIVE
CHECK PLAYER FOR OBSTRUCTION BEHIND DOORS
NO
OBSTRUCTION FOUND
YES
TRY A KNOWN GOOD TAPE
CORRECT AS REQUIRED
PLAYS OK?
REMOVE UNIT FOR REPAIR
ADVISE OWNER OF WORN OR DEFECTIVE TAPE
POOR PERFORMANCE
TRY A KNOWN GOOD TAPE
NO
PLAYS OK?
YES
REMOVE UNIT FOR REPAIR
ADVISE OWNER OF WORN OR DEFECTIVE TAPE

IF TAPE IS IN BUT AUDIO DEAD THEN PUSH CASSETTE INTO PLAY POSITION WITH FINGER THEN PROCEED

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TROUBLE SHOOTING

- NO CRUISE CONTROL WHEN BUTTON PRESSED

  Slide switch in "OFF" position. Fuse blown, clutch switch clearance. Speed control throttle cable disconnected. Defective servo.

- NO RESUME WHEN SLIDE SWITCH MOVED

  Insufficient movement of slide switch. Faulty electrical circuit. Defective switch.

- NO AUTOMATIC RELEASE WITH BRAKE PEDAL DEPRESSED

  Speed control cable kinked or damaged. Improper adjustment of brake switch. Faulty electrical circuit. Defective servo

- CRUISE CONTROL ENGAGES WITHOUT ACTUATING SPEED SET BUTTON

  Faulty electrical circuit. Defective servo.

- CARBURETOR DOES NOT RETURN TO NORMAL IDLE

  Speed control cable kinked or damaged. Speed control cable improperly adjusted. Standard throttle linkage faulty.

- SPEEDOMETER NOISE, EXCESSIVE NEEDLE FLUTTER OR ERRATIC SERVO LOCK-IN PERFORMANCE

  Speedometer cable kinked or damaged. Cable core bent or too long. Cable ferrule nut loose at speedometer head, transmission or cruise control servo. No lubrication on speedometer cable or core. Noisy speedometer head assembly. Defective servo.

- SPEED SETTING AFTER LOCK-IN IS TOO HIGH OR TOO LOW

  Improper cruise control throttle cable adjustment. Vacuum leak. Improper cruise control lock-in adjustment. Defective servo.

- UNIT DISENGAGES ON ROUGH ROAD

  Insufficient brake or clutch switch clearance. Defective brake or clutch switch. Faulty electrical circuit.

- RESUME SPEED POSSIBLE BELOW 20 MPH.

  Faulty electrical circuit. Defective servo.

- CRUISE CONTROL ENGAGES WHEN ENGINE STARTED OR DOES NOT DISENGAGE WITH PEDAL DEPRESSED

  Faulty electrical circuit. Defective servo.

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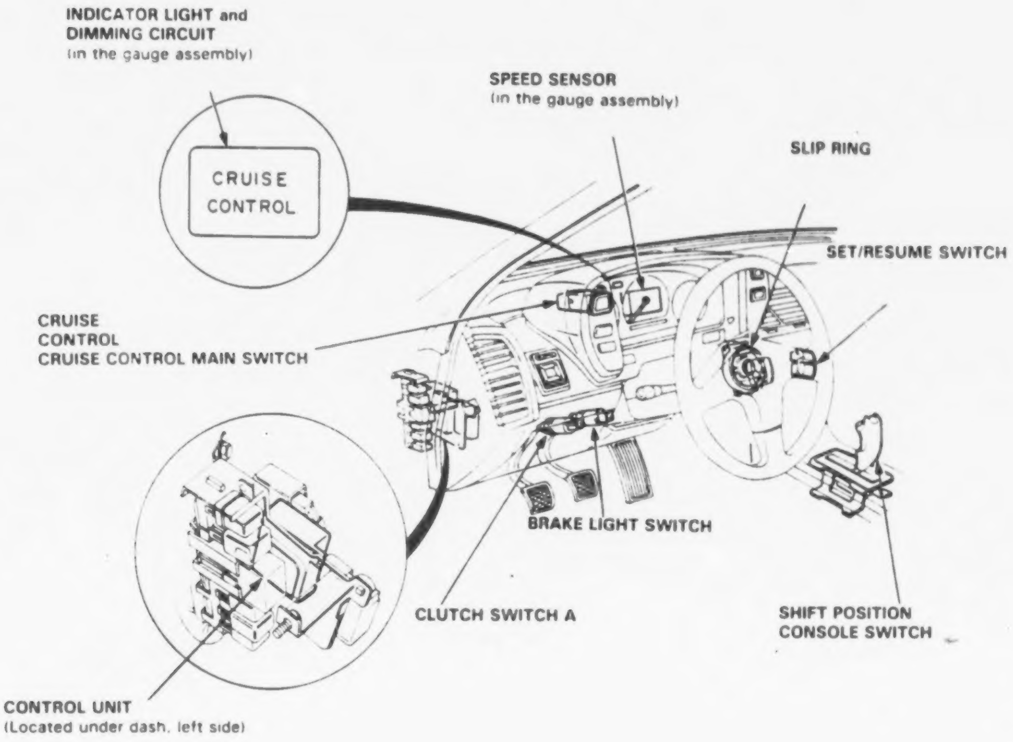
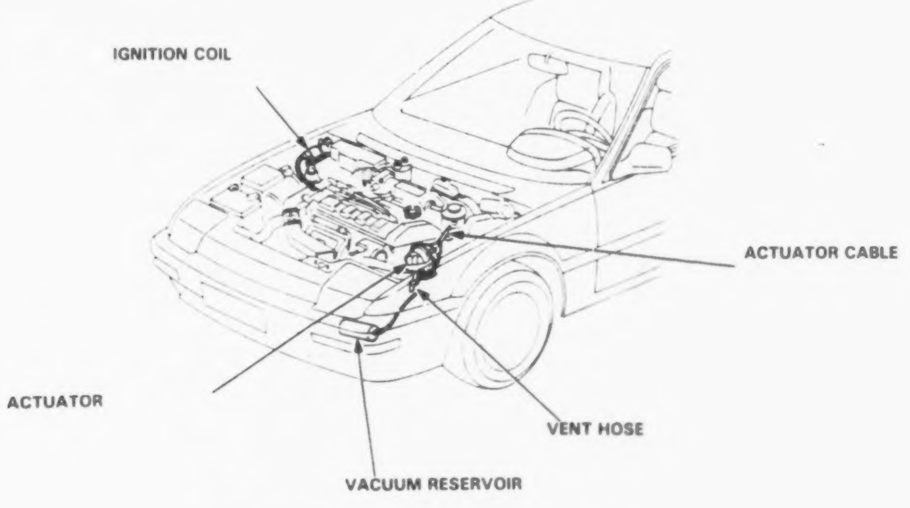
Cruise Control

Component Location Index


INDICATOR LIGHT and DIMMING CIRCUIT (in the gauge assembly)
SPEED SENSOR (in the gauge assembly)
SLIP RING
CRUISE CONTROL
SET/RESUME SWITCH
CRUISE CONTROL
CRUISE CONTROL MAIN SWITCH
BRAKE LIGHT SWITCH
CLUTCH SWITCH A
SHIFT POSITION CONSOLE SWITCH
CONTROL UNIT (Located under dash, left side)


IGNITION COIL
ACTUATOR CABLE
ACTUATOR
VENT HOSE
VACUUM RESERVOIR

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COUGAR & THUNDERBIRD

COMPONENT LOCATOR:

A/C COMP CLUTCH (2.3L)	E 38
A/C HTR SW (MANUAL A/C)	D 33-34
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BATTERY	A 1
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BRAKE FLUID LVL SW	B 28
CLOCK	D 49
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CLUTCH SWITCH	A 3
CORNERING LT RLY	D-E 37
CRUISE CTRL AMP	F 28-29
DIGITAL INST CLSTR	A-E 46-47
DISTRIBUTOR (2.3L)	D 4
DISTRIBUTOR (3.8L)	E 4
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DRIVERS SEAT CTRL SW	D-F 56
DRIVERS SEAT CTRL SWITCH (MEMORY)	D-F 52
DRIVERS SEAT MEMORY MOD	F 53-54
ELECT CTRL ASSY (2.3L)	A-E 4-5
ELECT CTRL ASSY (3.8L)	A-E 9-10
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MULTI-FUNCTION SWITCH	D-E 38-39
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PWR WINDOW SWITCH	C 58
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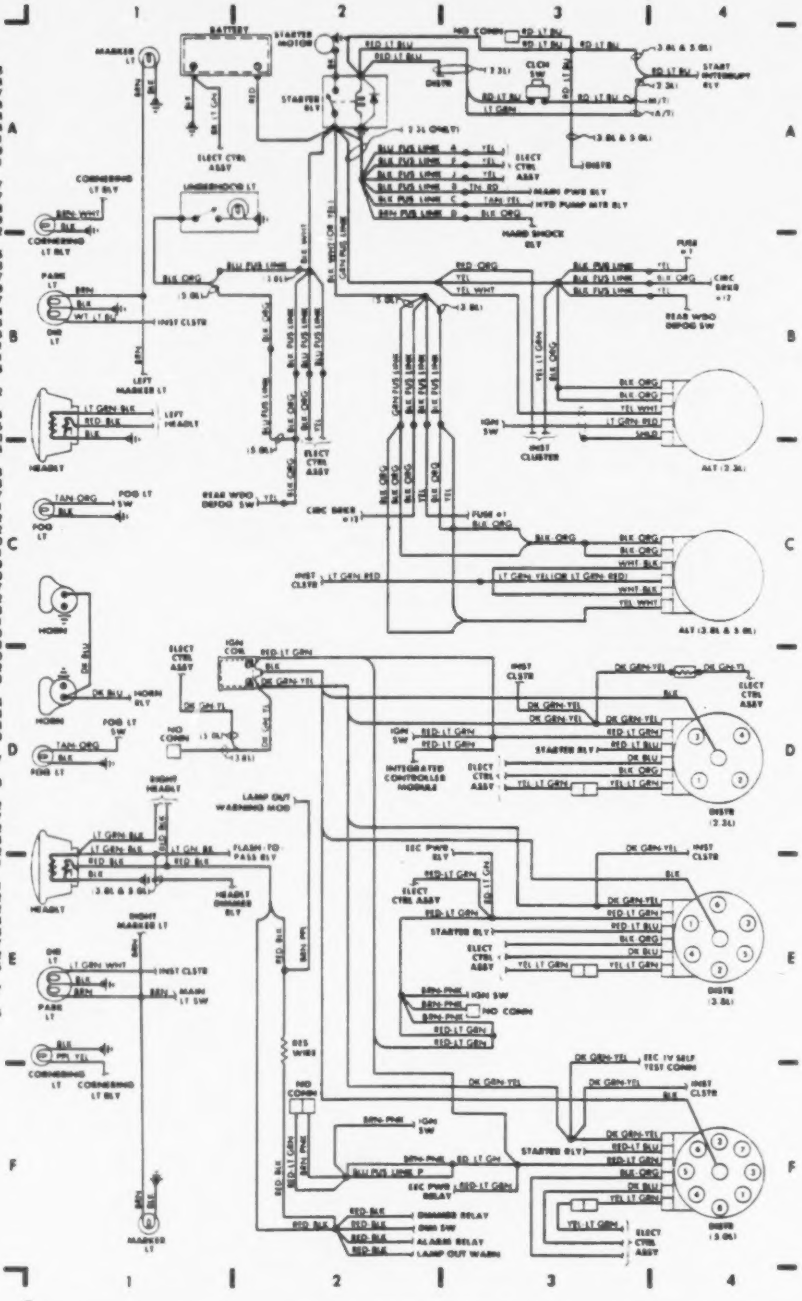
WOT A/C CUTOUT RLY (MANUAL A/C)	F 34-35


1
2
3
4
A
B
C
D
E
F
BATTERY
STARTER MOTOR
STARTER RLY
MARKER LT
CORNERING LT RLY
UNDERHOOD LT
PARK LT
DIR LT
LEFT MARKER LT
HEADLT
FOG LT
HORN
HORN RLY
FOG LT SW
IGN COIL
ELECT CTRL ASSY
INTEGRATED CONTROLLER MODULE
RIGHT HEADLT
LAMP OUT WARNING MOD
FLASH-TO-PASS RLY
HEADLT DIMMER RLY
RIGHT MARKER LT
INST CLSTR
MAIN LT SW
HARD SHOCK RLY
MAIN PWR RLY
HYD PUMP MTR RLY
START INTERRUPT RLY
REAR WDO DEFOG SW
CIRC BRKR
ALT (2.3L)
ALT (3.8L & 5.0L)
DISTR (2.3L)
DISTR (3.8L)
DISTR (5.0L)
EEC IV SELF TEST CONN
EEC PWR RELAY
DIMMER RELAY
DIM SW
ALARM RELAY
LAMP OUT WARN
RES WIRE
NO CONN
IGN SW

ENGINE COMPARTMENT

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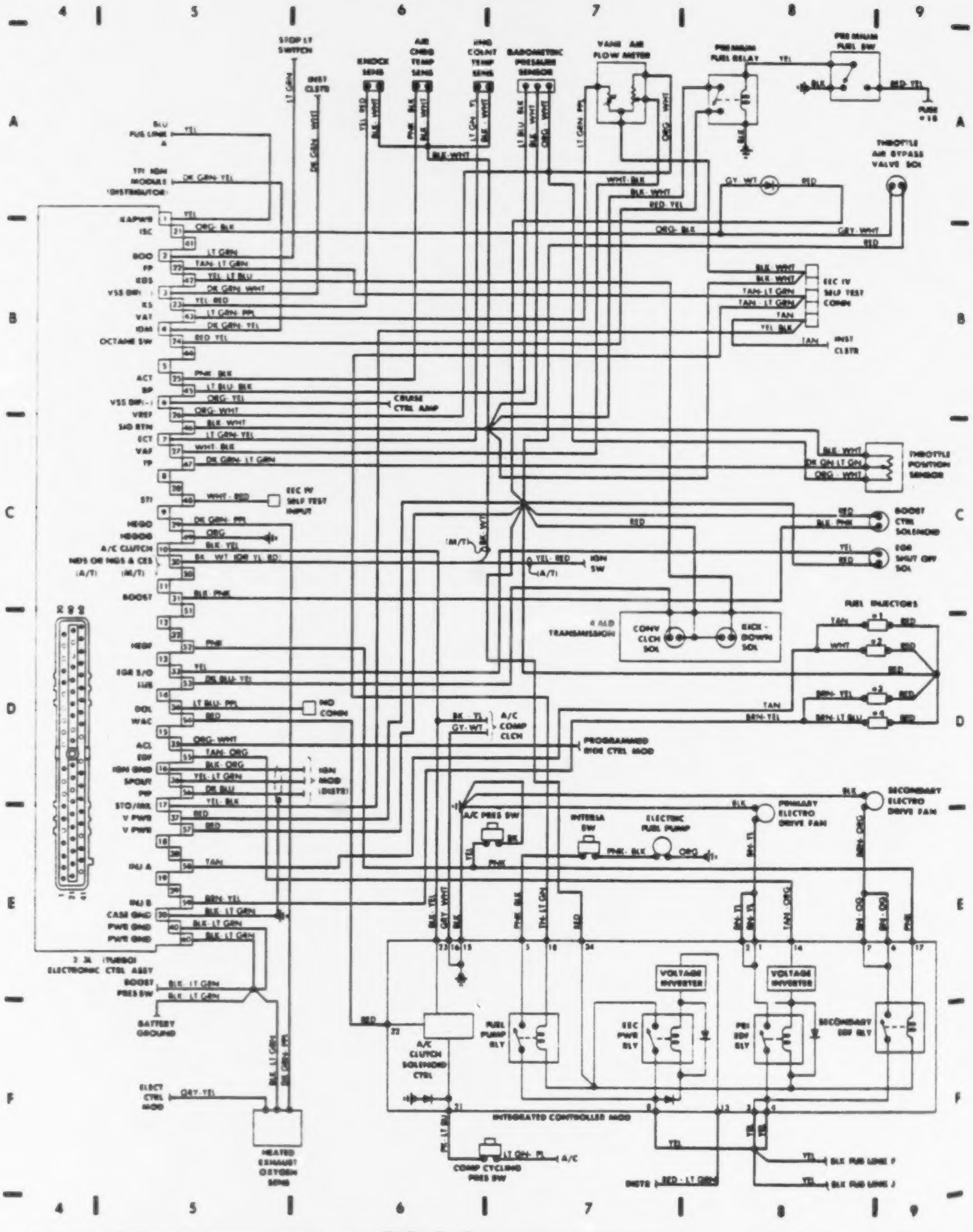
COUGAR & THUNDERBIRD (Cont.)


4
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D
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F
STOP LT SWITCH
INST CLSTR
KNOCK SENS
AIR CHRG TEMP SENS
ENG COLNT TEMP SENS
BAROMETRIC PRESSURE SENSOR
VANE AIR FLOW METER
PREMIUM FUEL RELAY
PREMIUM FUEL SW
FUSE 18
THROTTLE AIR BYPASS VALVE SOL
BLU FUS LINK A
TFI IGN MODULE (DISTRIBUTOR)
KAPWR
ISC
BOO
FP
KOS
VSS (DIF) (+)
KS
VAT
IDM
OCTANE SW
ACT
BP
VSS (DIF) (-)
VREF
SIG RTN
ECT
VAF
TP
STI
HEGO
HEGOG
A/C CLUTCH
NDS OR NGS & CES (A/T) (M/T)
BOOST
NEGF
EGR S/O
LUS
DOL
WAC
ACL
EDF
IGN GND
SPOUT
PIP
STO/MIL
V PWR
V PWR
INJ A
INJ B
CASE GND
PWR GND
PWR GND
2.3L (TURBO) ELECTRONIC CTRL ASSY
BOOST PRES SW
BATTERY GROUND
ELECT CTRL MOD
HEATED EXHAUST OXYGEN SENS
EEC IV SELF TEST INPUT
CRUISE CTRL AMP
EEC IV SELF TEST CONN
INST CLSTR
THROTTLE POSITION SENSOR
BOOST CTRL SOLENOID
EGR SHUT OFF SOL
IGN SW
(M/T)
(A/T)
4 ALD TRANSMISSION
CONV CLCH SOL
KICK-DOWN SOL
FUEL INJECTORS
#1
#2
#3
#4
NO CONN
A/C COMP CLCH
PROGRAMMED RIDE CTRL MOD
IGN MOD (DISTR)
A/C PRES SW
INTERIA SW
ELECTRIC FUEL PUMP
PRIMARY ELECTRO DRIVE FAN
SECONDARY ELECTRO DRIVE FAN
VOLTAGE INVERTER
VOLTAGE INVERTER
A/C CLUTCH SOLENOID CTRL
FUEL PUMP RLY
EEC PWR RLY
PRI EDF RLY
SECONDARY EDF RLY
INTEGRATED CONTROLLER MOD
COMP CYCLING PRES SW
A/C
DISTR
BLK FUS LINK F
BLK FUS LINK J
LT GRN
DK GRN-WHT
YEL-RED
BLK-WHT
PNK-BLK
LT GRN-YEL
LT BLU-BLK
ORG-WHT
WHT-BLK
RED-YEL
ORG-BLK
GRY-WHT
RED
TAN-LT GRN
YEL-LT BLU
DK GRN-YEL
YEL-BLK
TAN
LT GRN-PPL
DK GRN-LT GRN
WHT-RED
DK GRN-PPL
ORG
BLK-YEL
BLK-PNK
PNK
YEL
DK BLU-YEL
LT BLU-PPL
TAN-ORG
BLK-ORG
YEL-LT GRN
DK BLU
BRN-YEL
BLK-LT GRN
BRN-LT BLU
WHT
GRY-YEL
RED-LT GRN
ENGINE COMPARTMENT

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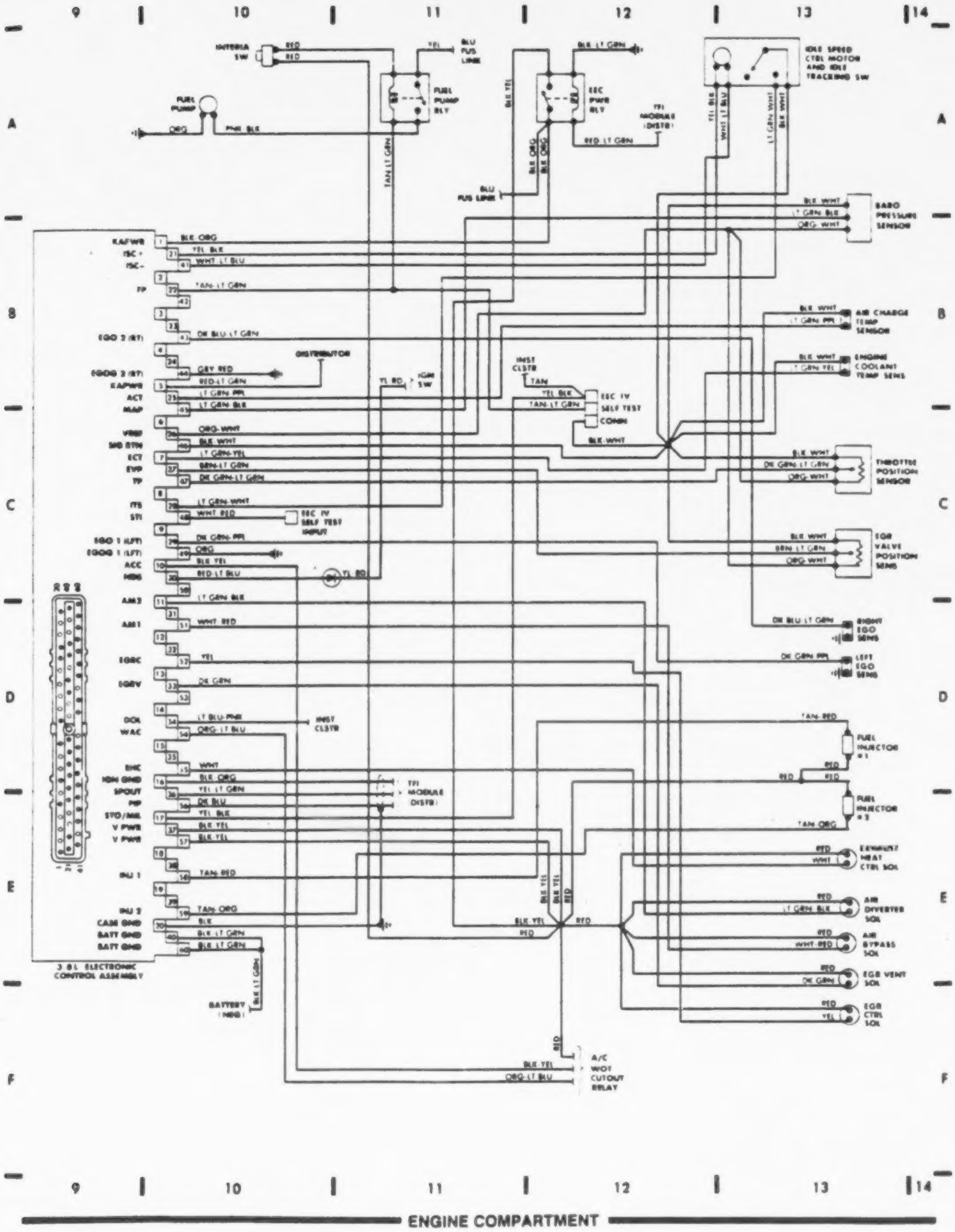
COUGAR & THUNDERBIRD (Cont.)


9
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F
INERTIA SW
RED
YEL
BLU FUS LINK
FUEL PUMP RLY
FUEL PUMP
ORG
PNK BLK
TAN LT GRN
BLK YEL
BLK LT GRN
EEC PWR RLY
TFI MODULE (DISTR)
RED LT GRN
BLK ORG
BLU FUS LINK
IDLE SPEED CTRL MOTOR AND IDLE TRACKING SW
YEL BLK
WHT LT BLU
LT GRN WHT
BLK WHT
KAPWR
ISC +
ISC -
FP
EGO 2 (RT)
EGOG 2 (RT)
KAPWR
ACT
MAP
VREF
SIG RTN
ECT
EVP
TP
ITS
STI
EGO 1 (LFT)
EGOG 1 (LFT)
ACC
HDG
AM2
AM1
EGRC
EGRV
DOL
WAC
EHC
IGN GND
SPOUT
PIP
STO/MIL
V PWR
V PWR
INJ 1
INJ 2
CASE GND
BATT GND
BATT GND
3.8L ELECTRONIC CONTROL ASSEMBLY
BLK ORG
YEL BLK
WHT LT BLU
TAN-LT GRN
DK BLU-LT GRN
DISTRIBUTOR
GRY RED
RED-LT GRN
LT GRN PPL
LT GRN BLK
ORG-WHT
BLK WHT
LT GRN-YEL
BRN-LT GRN
DK GRN-LT GRN
LT GRN-WHT
WHT RED
EEC IV SELF TEST INPUT
DK GRN-PPL
ORG
BLK YEL
RED-LT BLU
YL RD
IGN SW
LT GRN BLK
WHT RED
YEL
DK GRN
LT BLU-PNK
INST CLSTR
ORG-LT BLU
WHT
BLK ORG
YEL LT GRN
DK BLU
YEL BLK
BLK YEL
BLK YEL
TFI MODULE (DISTR)
TAN-RED
TAN-ORG
BLK
BLK LT GRN
BLK LT GRN
BATTERY (NEG)
BLK LT GRN
INST CLSTR
TAN
YEL BLK
TAN-LT GRN
EEC IV SELF TEST CONN
BLK-WHT
BLK WHT
LT GRN BLK
ORG-WHT
BARO PRESSURE SENSOR
BLK WHT
LT GRN PPL
AIR CHARGE TEMP SENSOR
BLK WHT
LT GRN YEL
ENGINE COOLANT TEMP SENS
BLK WHT
DK GRN-LT GRN
ORG-WHT
THROTTLE POSITION SENSOR
BLK WHT
BRN LT GRN
ORG-WHT
EGR VALVE POSITION SENS
DK BLU LT GRN
RIGHT EGO SENS
DK GRN PPL
LEFT EGO SENS
TAN-RED
FUEL INJECTOR #1
RED
RED
RED
FUEL INJECTOR #2
TAN-ORG
RED
WHT
EXHAUST HEAT CTRL SOL
BLK YEL
BLK YEL
RED
BLK-YEL
RED
RED
RED
LT GRN BLK
AIR DIVERTER SOL
RED
WHT-RED
AIR BYPASS SOL
RED
DK GRN
EGR VENT SOL
RED
YEL
EGR CTRL SOL
RED
BLK-YEL
ORG-LT BLU
A/C WOT CUTOUT RELAY
ENGINE COMPARTMENT

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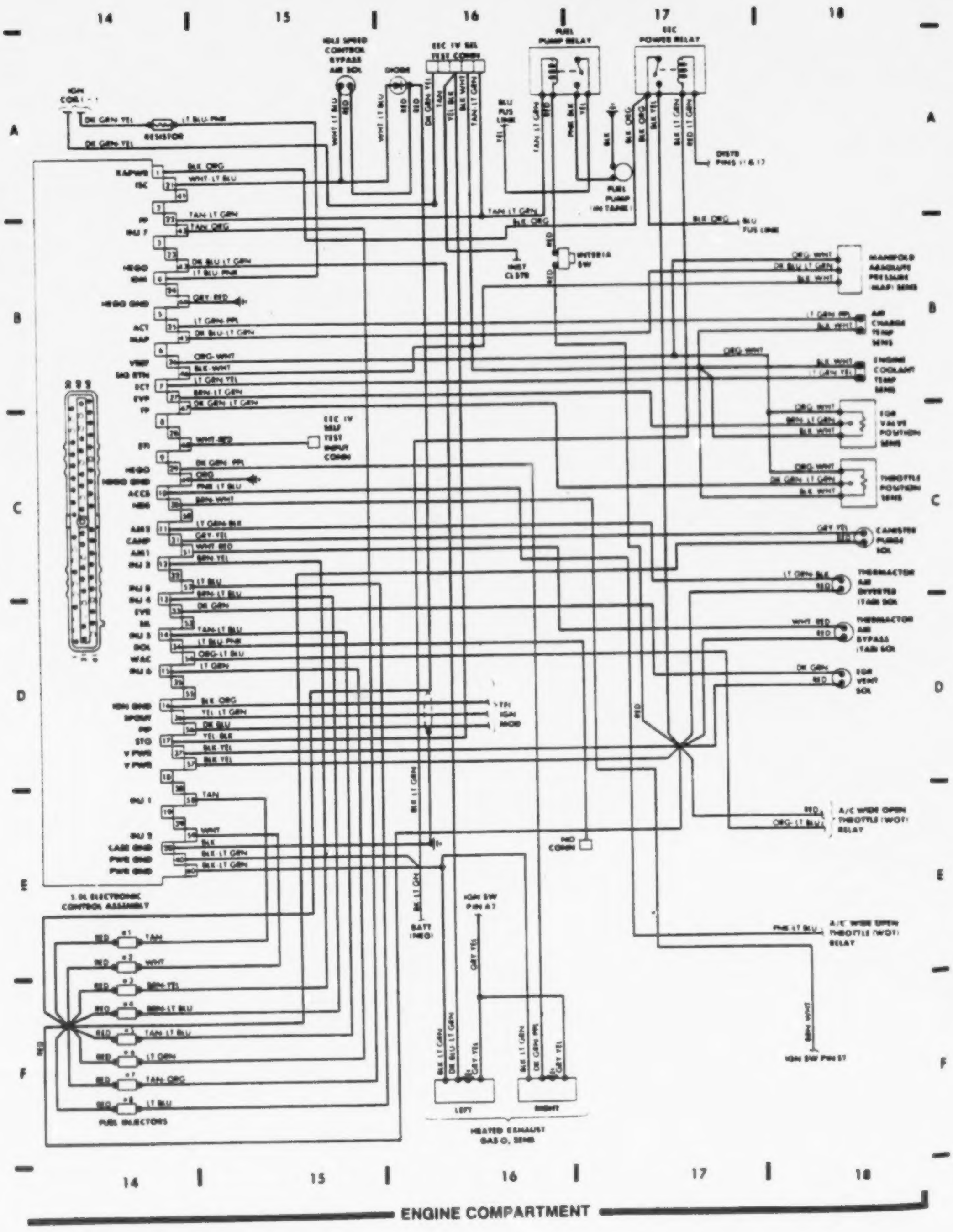
COUGAR & THUNDERBIRD (Cont.)



14
15
16
17
18
A
B
C
D
E
F
IGN COIL (-)
RESISTOR
IDLE SPEED CONTROL BYPASS AIR SOL
DIODE
EEC IV SEL TEST CONN
FUEL PUMP RELAY
EEC POWER RELAY
BLU FUS LINK
FUEL PUMP (IN TANK)
DISTR PINS 11 & 12
INST CLSTR
INERTIA SW
EEC IV SELF TEST INPUT CONN
MANIFOLD ABSOLUTE PRESSURE (MAP) SENS
AIR CHARGE TEMP SENS
ENGINE COOLANT TEMP SENS
EGR VALVE POSITION SENS
THROTTLE POSITION SENS
CANISTER PURGE SOL
THERMACTOR AIR DIVERTER (TAD) SOL
THERMACTOR AIR BYPASS (TAB) SOL
EGR VENT SOL
TFI IGN MOD
A/C WIDE OPEN THROTTLE (WOT) RELAY
NO CONN
BATT (NEG)
IGN SW PIN A7
IGN SW PIN S1
5.0L ELECTRONIC CONTROL ASSEMBLY
FUEL INJECTORS
LEFT
RIGHT
HEATED EXHAUST GAS O2 SENS
ENGINE COMPARTMENT

SUPPLEMENT 15 - ESS
IX - 59

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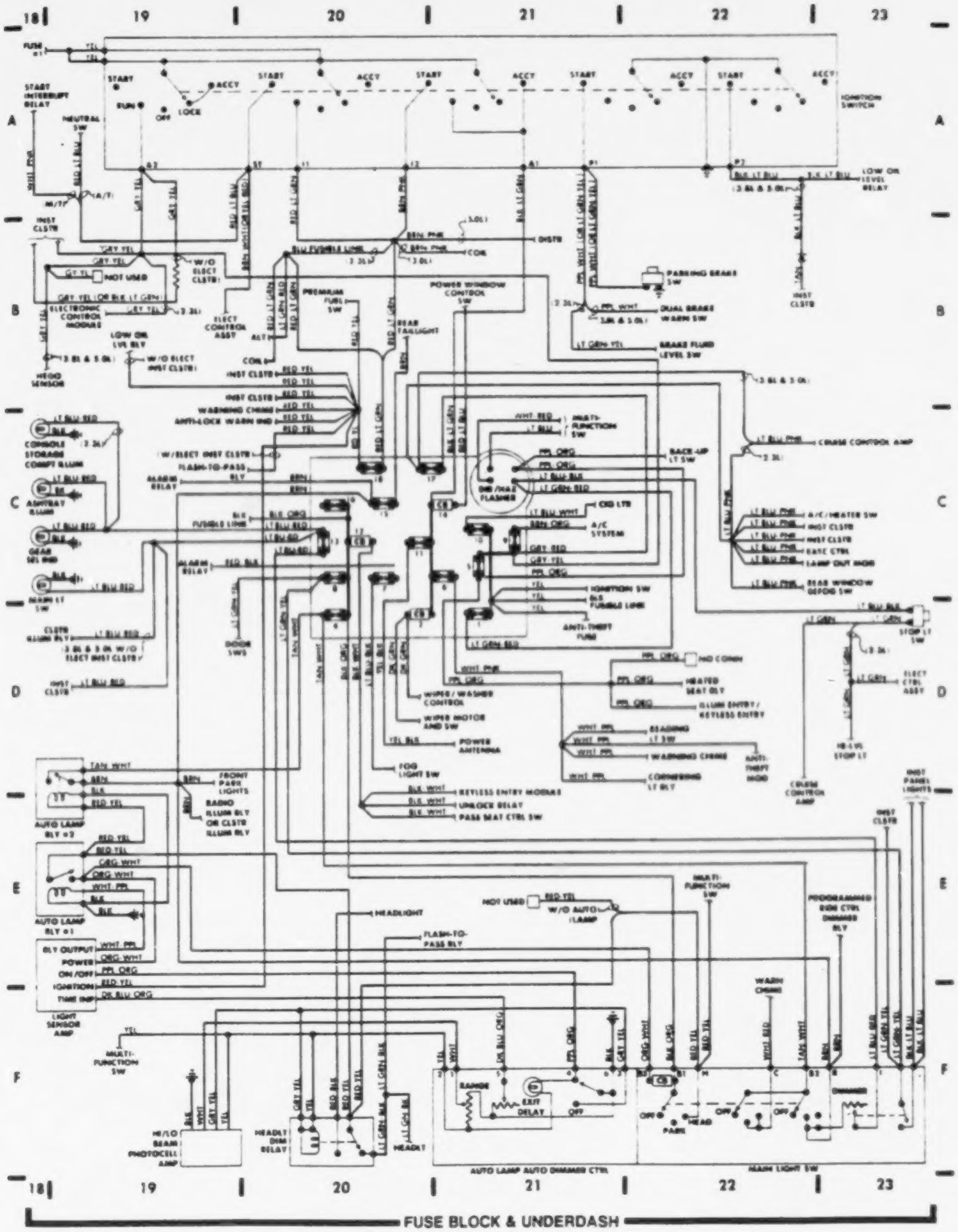
18
19
20
21
22
23
A
B
C
D
E
F
START INTERRUPT RELAY
NEUTRAL SW
START
ACCY
LOCK
RUN
OFF
IGNITION SWITCH
LOW OIL LEVEL RELAY
INST CLSTR
ELECTRONIC CONTROL MODULE
ELECT CONTROL ASSY
PREMIUM FUEL SW
POWER WINDOW CONTROL SW
PARKING BRAKE SW
DUAL BRAKE WARN SW
BRAKE FLUID LEVEL SW
HEGO SENSOR
CONSOLE STORAGE COMPT ILLUM
ASHTRAY ILLUM
GEAR SEL IND
MULTI-FUNCTION SW
BACK-UP LT SW
CRUISE CONTROL AMP
TURN/HAZ FLASHER
A/C SYSTEM
A/C/HEATER SW
INST CLSTR
EATC CTRL
LAMP OUT MOD
REAR WINDOW DEFOG SW
IGNITION SW
FUSIBLE LINK
ANTI-THEFT FUSE
DOOR SWS
STOP LT SW
ELECT CTRL ASSY
HI-LVL STOP LT
CRUISE CONTROL AMP
WIPER/WASHER CONTROL
WIPER MOTOR AND SW
POWER ANTENNA
FOG LIGHT SW
KEYLESS ENTRY MODULE
UNLOCK RELAY
PASS SEAT CTRL SW
HEATED SEAT RLY
ILLUM ENTRY/KEYLESS ENTRY
READING LT SW
WARNING CHIME
ANTI-THEFT MOD
CORNERING LT RLY
FRONT PARK LIGHTS
RADIO ILLUM RLY OR CLSTR ILLUM RLY
AUTO LAMP RLY #2
AUTO LAMP RLY #1
LIGHT SENSOR AMP
HEADLIGHT
FLASH-TO-PASS RLY
NOT USED
W/O AUTO LAMP
MULTI-FUNCTION SW
PROGRAMMED RIDE CTRL DIMMER RLY
INST PANEL LIGHTS
WARN CHIME
HI/LO BEAM PHOTOCELL AMP
HEADLT DIM RELAY
HEADLT
RANGE
EXIT DELAY
OFF
PARK
HEAD
DIMMER
AUTO LAMP AUTO DIMMER CTRL
MAIN LIGHT SW
FUSE BLOCK & UNDERDASH

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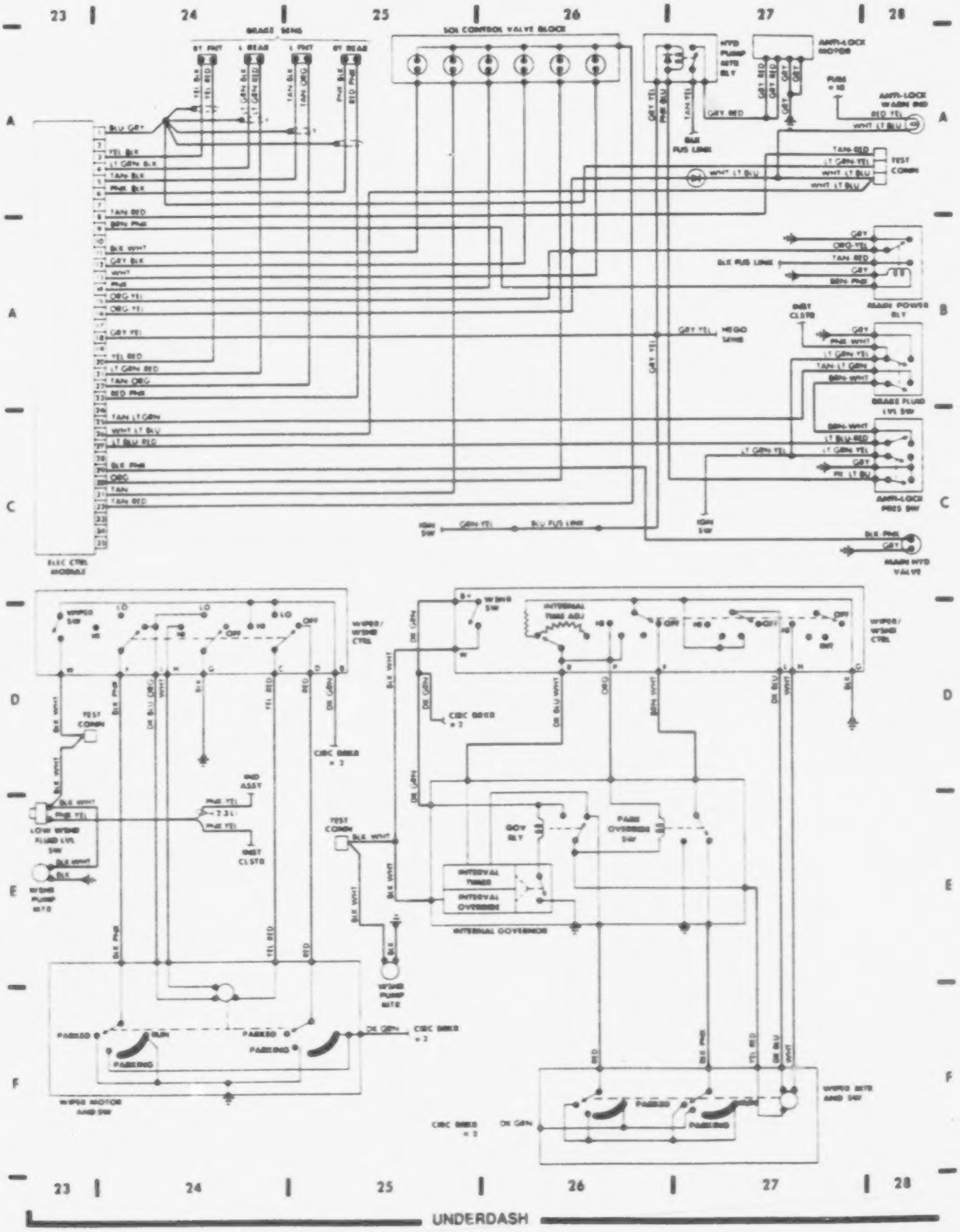
23
24
25
26
27
28
A
B
C
D
E
F
BRAKE SENS
SOL CONTROL VALVE BLOCK
HYD PUMP MTR RLY
ANTI-LOCK MOTOR
ANTI-LOCK WARN IND
TEST CONN
ELEC CTRL MODULE
MAIN POWER RLY
HEGO SENS
BRAKE FLUID LVL SW
ANTI-LOCK PRES SW
IGN SW
MAIN HYD VALVE
WIPER/WSHR CTRL
INTERNAL GOVERNOR
GOV RLY
PARK OVERRIDE SW
INTERVAL TIMER
INTERVAL OVERRIDE
LOW WSHR FLUID LVL SW
WSHR PUMP MTR
IND ASSY
INST CLSTR
CIRC BRKR #2
WIPER MOTOR AND SW
WIPER MTR AND SW
PARKED
PARKING
UNDERDASH

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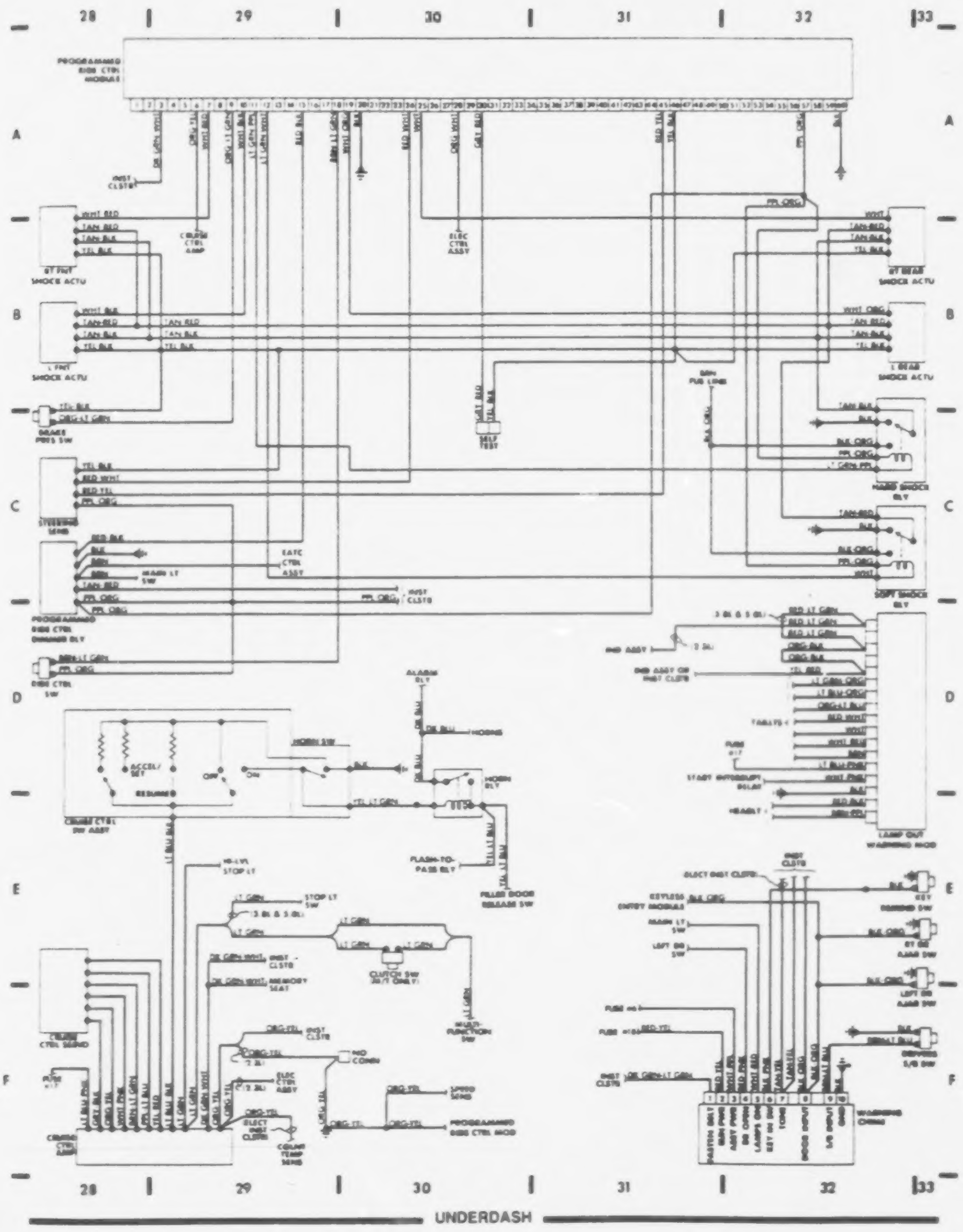
COUGAR & THUNDERBIRD (Cont.)


28
29
30
31
32
33
A
B
C
D
E
F
PROGRAMMED RIDE CTRL MODULE
INST CLSTR
CRUISE CTRL AMP
ELEC CTRL ASSY
RT FNT SHOCK ACTU
L FNT SHOCK ACTU
RT REAR SHOCK ACTU
L REAR SHOCK ACTU
WHT RED
TAN RED
TAN BLK
YEL BLK
WHT BLK
WHT ORG
WHT
BRAKE PRES SW
ORG LT GRN
SELF TEST
GRY RED
STEERING SENS
RED WHT
RED YEL
PPL ORG
RED BLK
BLK
BRN
MAIN LT SW
EATC CTRL ASSY
PROGRAMMED RIDE CTRL DAMPER RLY
RIDE CTRL SW
BRN LT GRN
BRN FUS LINK
BLK ORG
HARD SHOCK RLY
LT GRN PPL
SOFT SHOCK RLY
3.8L & 5.0L
3.8L
RED LT GRN
ORG BLK
YEL RED
IND ASSY
IND ASSY OR INST CLSTR
LT GRN ORG
LT BLU ORG
ORG LT BLU
TAILLTS
FUSE 17
START INTERRUPT RELAY
HEADLT
LAMP OUT WARNING MOD
ALARM RLY
DK BLU
HORNS
HORN SW
HORN RLY
ACCEL/SET
RESUME
OFF
ON
CRUISE CTRL SW ASSY
YEL LT GRN
FLASH-TO-PASS RLY
FILLER DOOR RELEASE SW
LT BLU BLK
HI-LVL STOP LT
STOP LT SW
LT GRN
CLUTCH SW (M/T ONLY)
MULTI-FUNCTION SW
DK GRN WHT
MEMORY SEAT
CRUISE CTRL SENS
ORG YEL
NO CONN
SPEED SENS
PROGRAMMED RIDE CTRL MOD
ELECT INST CLSTR
COOLANT TEMP SENS
CRUISE CTRL AMP
ELECT INST CLSTR
KEYLESS ENTRY MODULE
MAIN LT SW
LEFT DR SW
KEY WARNING SW
RT DR AJAR SW
LEFT DR AJAR SW
DRIVERS S/B SW
FUSE 1
FUSE 10
WARNING CHIME
1 2 3 4 5 6 7 8 9 10

UNDERDASH

SUPPLEMENT 15 - ESS
IX - 65

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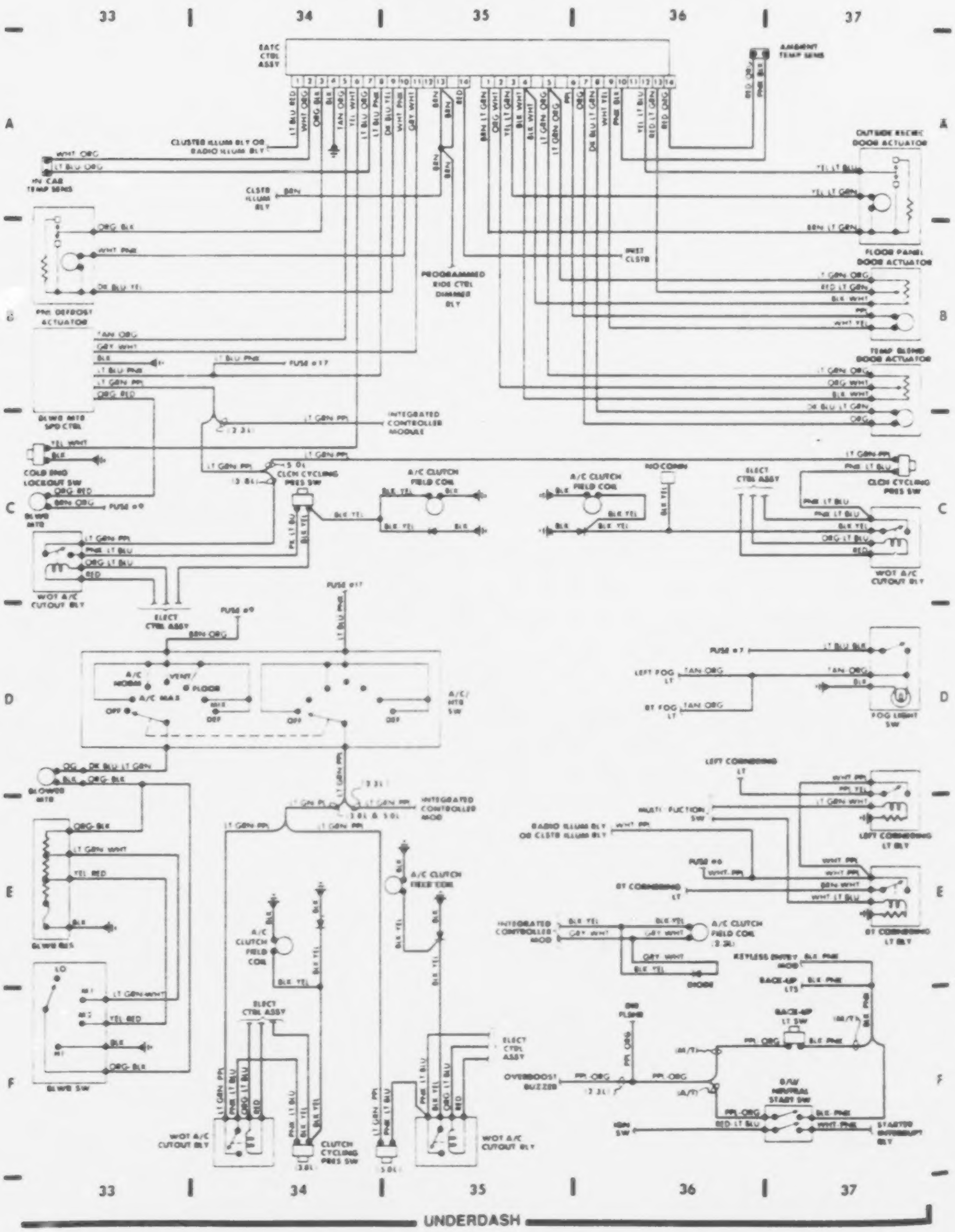
33
34
35
36
37
A
B
C
D
E
F
EATC CTRL ASSY
AMBIENT TEMP SENS
CLUSTER ILLUM RLY OR RADIO ILLUM RLY
IN CAR TEMP SENS
CLSTR ILLUM RLY
OUTSIDE RECIRC DOOR ACTUATOR
PNL DEFROST ACTUATOR
PROGRAMMED RIDE CTRL DIMMER RLY
FLOOR PANEL DOOR ACTUATOR
TEMP BLEND DOOR ACTUATOR
FUSE #17
BLWR MTR SPD CTRL
INTEGRATED CONTROLLER MODULE
COLD ENG LOCKOUT SW
CLCH CYCLING PRES SW
A/C CLUTCH FIELD COIL
NO CONN
ELECT CTRL ASSY
FUSE #9
BLWR MTR
WOT A/C CUTOUT RLY
A/C MODE
VENT
FLOOR
A/C MAX
OFF
A/C MTR SW
FUSE #7
LEFT FOG LT
RT FOG LT
FOG LIGHT SW
LEFT CORNERING LT
MULTI FUCTION SW
RADIO ILLUM RLY OR CLSTR ILLUM RLY
LEFT CORNERING LT RLY
FUSE #6
RT CORNERING LT
RT CORNERING LT RLY
BLWR RES
BLWR SW
LO
HI
INTEGRATED CONTROLLER MOD
DIODE
KEYLESS ENTRY MOD
BACK-UP LTS
BACK-UP LT SW
DIM PLSHR
OVERBOOST BUZZER
N/SW NEUTRAL START SW
IGN SW
STARTER INTERRUPT RLY
CLUTCH CYCLING PRES SW
UNDERDASH

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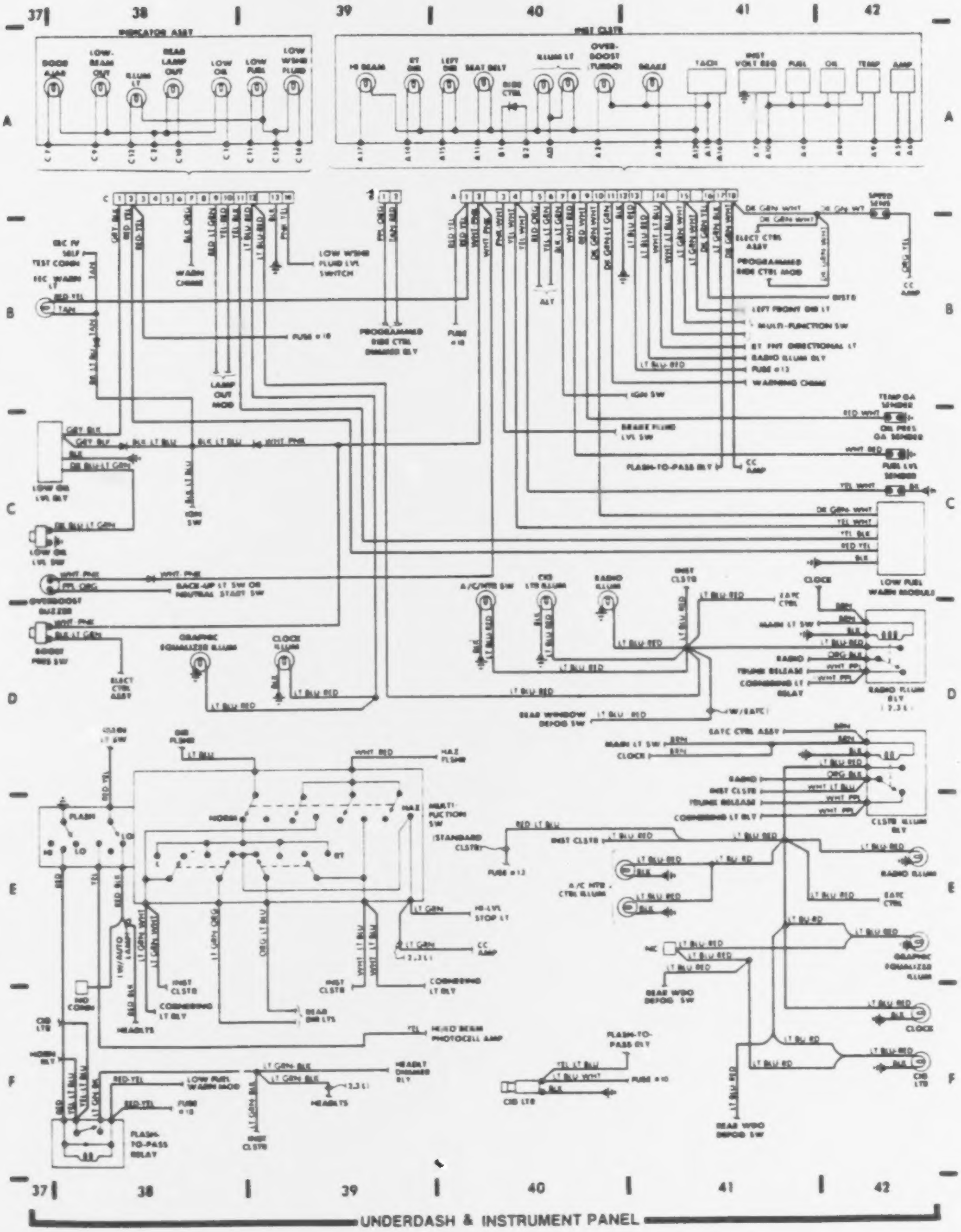
37
38
39
40
41
42
A
B
C
D
E
F
INDICATOR ASSY
INST CLSTR
DOOR AJAR
LOW BEAM OUT
ILLUM LT
REAR LAMP OUT
LOW OIL
LOW FUEL
LOW WSHD FLUID
HI BEAM
RT DIR
LEFT DIR
SEAT BELT
ILLUM LT
OVERBOOST (TURBO)
BRAKE
TACH
INST VOLT REG
FUEL
OIL
TEMP
AMP
LOW WSHD FLUID LVL SWITCH
WARN CHIME
PROGRAMMED RIDE CTRL DIMMED RLY
LAMP OUT MOD
LEFT FRONT DIR LT
MULTI-FUNCTION SW
RT FNT DIRECTIONAL LT
RADIO ILLUM RLY
FUSE #13
WARNING CHIME
IGN SW
BRAKE FLUID LVL SW
FLASH-TO-PASS RLY
CC AMP
SPEED SENS
ELECT CTRL ASSY
PROGRAMMED RIDE CTRL MOD
DISTR
TEMP GA SENDER
OIL PRES GA SENDER
FUEL LVL SENDER
LOW FUEL WARN MODULE
LOW OIL LVL RLY
LOW OIL LVL SW
BACK-UP LT SW OR NEUTRAL START SW
OVERBOOST BUZZER
BOOST PRES SW
ELECT CTRL ASSY
GRAPHIC EQUALIZER ILLUM
CLOCK ILLUM
A/C-HTR SW
RADIO ILLUM
INST CLSTR
EATC CTRL
CLOCK
MAIN LT SW
RADIO
TRUNK RELEASE
CORNERING LT RELAY
RADIO ILLUM RLY
REAR WINDOW DEFOG SW
EATC CTRL ASSY
CLSTR ILLUM RLY
MULTI-FUCTION SW
HAZ FLSHR
HAZ
FLASH
NORM
HI-LVL STOP LT
CC AMP
CORNERING LT RLY
REAR DIR LTS
HEAD BEAM PHOTOCELL AMP
HEADLT DIMMER RLY
HEADLTS
LOW FUEL WARN MOD
FUSE #10
FLASH-TO-PASS RELAY
FUSE #13
RADIO ILLUM
EATC CTRL
A/C HTR CTRL ILLUM
GRAPHIC EQUALIZER ILLUM
REAR WDO DEFOG SW
CLOCK
CIG LTR
FLASH-TO-PASS RLY
UNDERDASH & INSTRUMENT PANEL

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600

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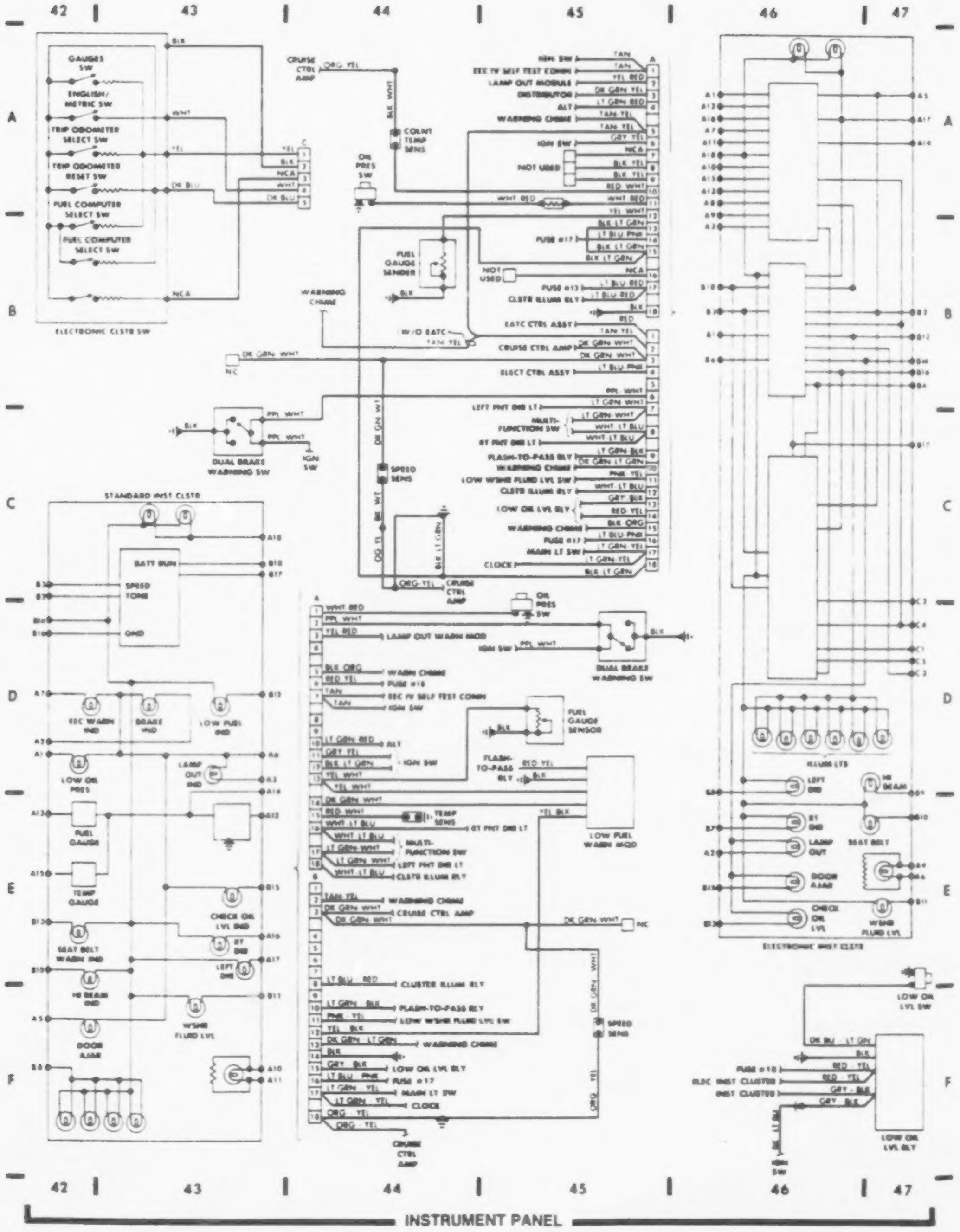
42
43
44
45
46
47
A
B
C
D
E
F
GAUGES SW
ENGLISH/ METRIC SW
TRIP ODOMETER SELECT SW
TRIP ODOMETER RESET SW
FUEL COMPUTER SELECT SW
FUEL COMPUTER SELECT SW
ELECTRONIC CLSTR SW
CRUISE CTRL AMP
COLNT TEMP SENS
OIL PRES SW
FUEL GAUGE SENDER
WARNING CHIME
W/O EATC
DUAL BRAKE WARNING SW
SPEED SENS
NEU SW
EEC IV SELF TEST CONN
LAMP OUT MODULE
DISTRIBUTOR
ALT
WARNING CHIME
IGN SW
NOT USED
FUSE #17
CLSTR ILLUM RLY
EATC CTRL ASSY
CRUISE CTRL AMP
ELECT CTRL ASSY
LEFT FRNT DIR LT
MULTI-FUNCTION SW
RT FRNT DIR LT
FLASH-TO-PASS RLY
LOW WSHR FLUID LVL SW
LOW OIL LVL RLY
MAIN LT SW
CLOCK
STANDARD INST CLSTR
BATT RUN
SPEED TONE
GND
EEC WARN IND
BRAKE IND
LOW FUEL IND
LOW OIL PRES
LAMP OUT IND
FUEL GAUGE
TEMP GAUGE
CHECK OIL LVL IND
SEAT BELT WARN IND
RT DIR
LEFT DIR
HI BEAM IND
WSHR FLUID LVL
DOOR AJAR
LAMP OUT WARN MOD
WARN CHIME
FUSE #18
FUEL GAUGE SENSOR
FLASH-TO-PASS RLY
TEMP SENS
LOW FUEL WARN MOD
CLUSTER ILLUM RLY
ILLUM LTS
HI BEAM
SEAT BELT
CHECK OIL LVL
ELECTRONIC INST CLSTR
LOW OIL LVL SW
FUSE #18
ELEC INST CLUSTER
INST CLUSTER
LOW OIL LVL RLY
IGN SW
INSTRUMENT PANEL

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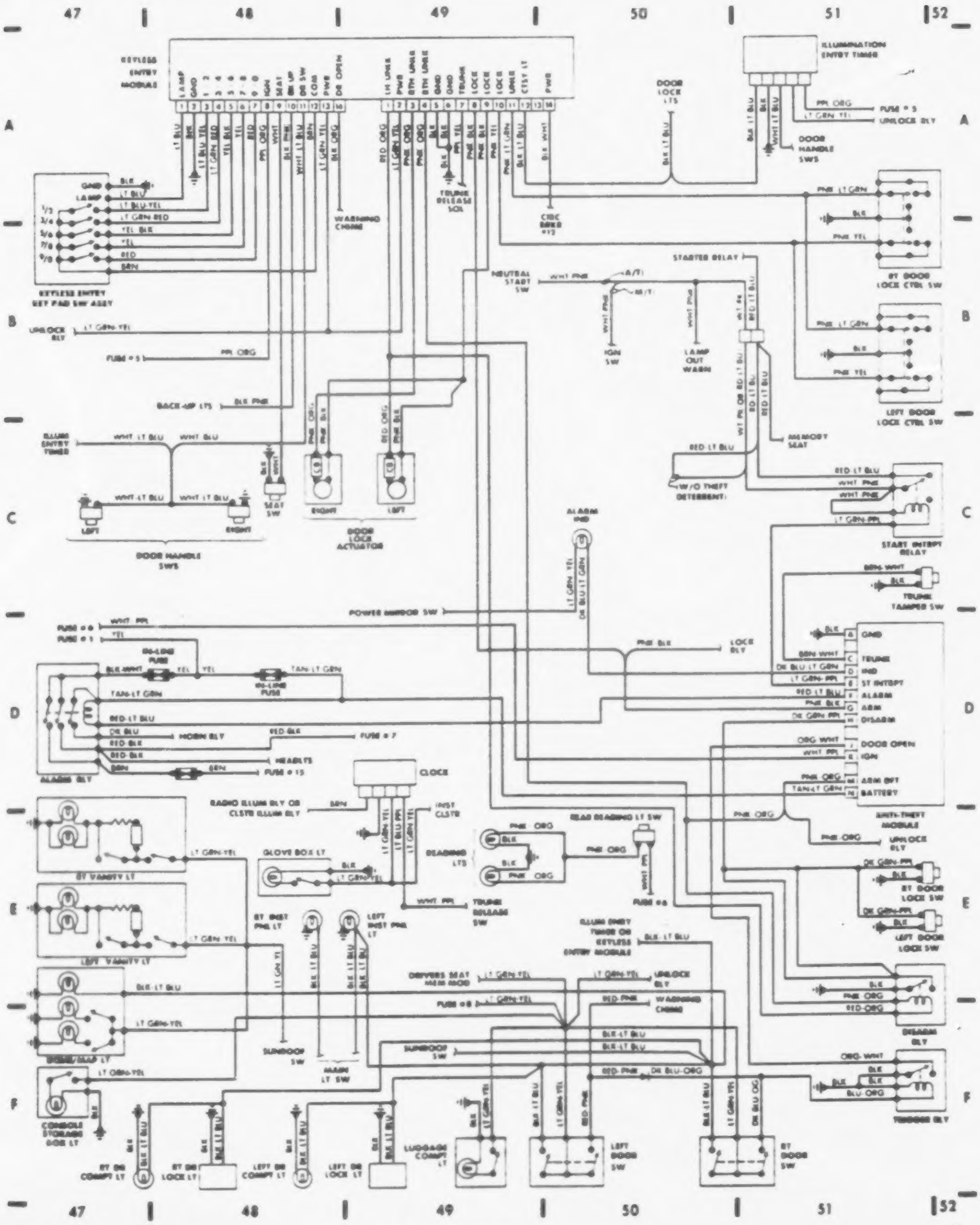
47
48
49
50
51
52
A
B
C
D
E
F
KEYLESS ENTRY MODULE
LAMP
GND
1 2
3 4
5 6
7 8
9 0
IGN
SEAT
BK UP
DR SW
COM
PWR
DR OPEN
LH UNLK
PWR
RTH UNLK
RTH UNLK
GND
GND
TRUNK
LOCK
LOCK
LOCK
UNLK
CTSY LT
PWR
ILLUMINATION ENTRY TIMER
FUSE # 5
UNLOCK RLY
DOOR HANDLE SWS
DOOR LOCK LTS
KEYLESS ENTRY KEY PAD SW ASSY
WARNING CHIME
TRUNK RELEASE SOL
CIRC BRKR #12
RT DOOR LOCK CTRL SW
LEFT DOOR LOCK CTRL SW
NEUTRAL START SW
STARTER RELAY
A/T
M/T
IGN SW
LAMP OUT WARN
MEMORY SEAT
W/O THEFT DETERRENT
UNLOCK RLY
FUSE # 5
BACK-UP LTS
ILLUM ENTRY TIMER
SEAT SW
DOOR HANDLE SWS
LEFT
RIGHT
DOOR LOCK ACTUATOR
START INTRPT RELAY
ALARM IND
TRUNK TAMPER SW
POWER MIRROR SW
LOCK RLY
FUSE # 6
FUSE # 1
IN-LINE FUSE
HORN RLY
FUSE # 7
HEADLTS
FUSE # 15
ALARM RLY
CLOCK
RADIO ILLUM RLY OR CLSTR ILLUM RLY
INST CLSTR
GND
TRUNK
IND
ST INTRPT
ALARM
ARM
DISARM
DOOR OPEN
IGN
ARM OPT
BATTERY
ANTI-THEFT MODULE
UNLOCK RLY
REAR READING LT SW
READING LTS
FUSE # 6
RT VANITY LT
GLOVE BOX LT
TRUNK RELEASE SW
LEFT VANITY LT
RT INST PNL LT
LEFT INST PNL LT
RT DOOR LOCK SW
LEFT DOOR LOCK SW
ILLUM ENTRY TIMER OR KEYLESS ENTRY MODULE
DRIVERS SEAT MEM MOD
UNLOCK RLY
FUSE # 8
WARNING CHIME
DISARM RLY
DOME/MAP LT
SUNROOF SW
MAIN LT SW
SUNROOF SW
TRIGGER RLY
CONSOLE STORAGE BOX LT
RT DR COMPT LT
RT DR LOCK LT
LEFT DR COMPT LT
LEFT DR LOCK LT
LUGGAGE COMPT LT
LEFT DOOR SW
RT DOOR SW

REAR COMPARTMENT & ACCESSORIES

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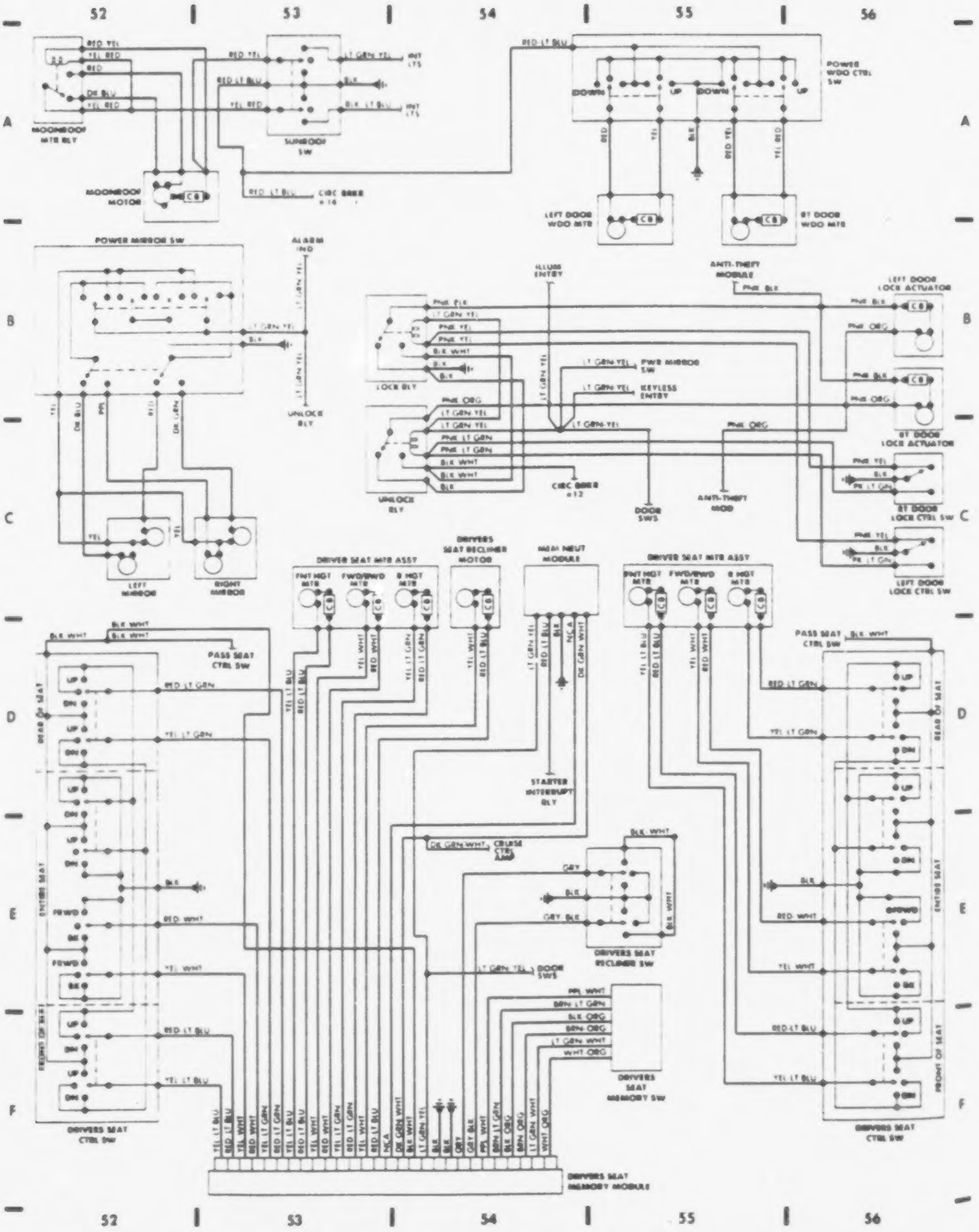
COUGAR & THUNDERBIRD (Cont.)


52
53
54
55
56
A
B
C
D
E
F
MOONROOF MTR RLY
SUNROOF SW
MOONROOF MOTOR
CIRC BRKR
POWER WDO CTRL SW
DOWN
UP
LEFT DOOR WDO MTR
RT DOOR WDO MTR
POWER MIRROR SW
ALARM IND
UNLOCK RLY
LEFT MIRROR
RIGHT MIRROR
ILLUM ENTRY
ANTI-THEFT MODULE
LEFT DOOR LOCK ACTUATOR
RT DOOR LOCK ACTUATOR
LOCK RLY
PWR MIRROR SW
KEYLESS ENTRY
CIRC BRKR
DOOR SWS
ANTI-THEFT MOD
RT DOOR LOCK CTRL SW
LEFT DOOR LOCK CTRL SW
DRIVER SEAT MTR ASSY
FRNT HGT MTR
FWD/RWD MTR
R HGT MTR
DRIVERS SEAT RECLINER MOTOR
NEUT MODULE
STARTER INTERRUPT RLY
CRUISE CTRL AMP
DRIVERS SEAT RECLINER SW
DOOR SWS
DRIVERS SEAT MEMORY SW
DRIVERS SEAT MEMORY MODULE
PASS SEAT CTRL SW
DRIVERS SEAT CTRL SW
REAR OF SEAT
ENTIRE SEAT
FRONT OF SEAT
UP
DN
FRWD
BK

REAR COMPARTMENT & ACCESSORIES

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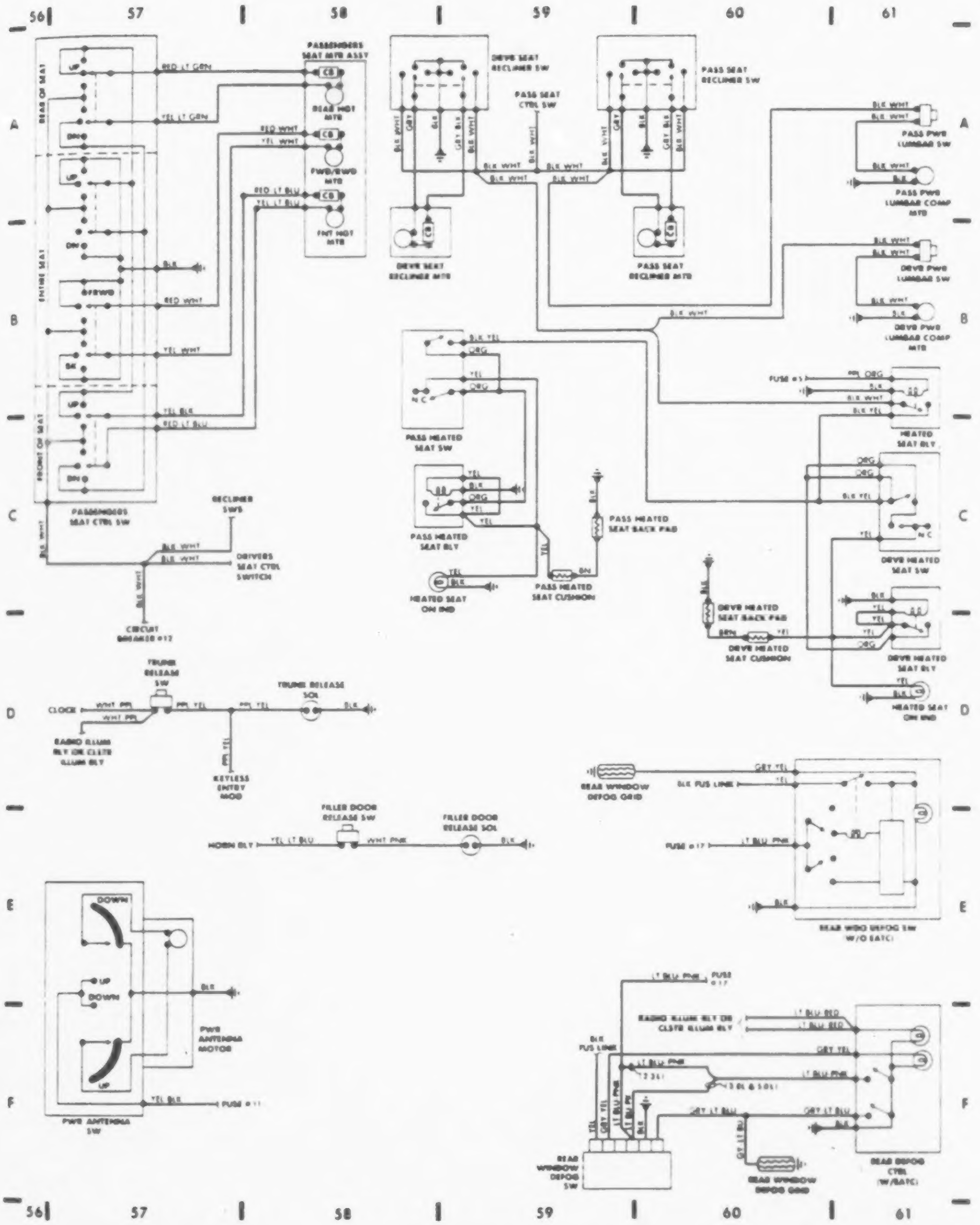
COUGAR & THUNDERBIRD (Cont.)


56
57
58
59
60
61
A
B
C
D
E
F
REAR OF SEAT
ENTIRE SEAT
FRONT OF SEAT
UP
DN
UP
DN
BFRWD
BK
UP
DN
RED LT GRN
YEL LT GRN
RED WHT
YEL WHT
RED LT BLU
YEL LT BLU
BLK
RED WHT
YEL WHT
YEL BLK
RED LT BLU
PASSENGERS SEAT MTR ASSY
CB
REAR HGT MTR
FWD/RWD MTR
FNT HGT MTR
PASSENGERS SEAT CTRL SW
BLK WHT
RECLINER SWS
BLK WHT
BLK WHT
DRIVERS SEAT CTRL SWITCH
BLK WHT
CIRCUIT BREAKER #12
DRVR SEAT RECLINER SW
BLK WHT
GRY
BLK
GRY BLK
BLK WHT
DRVR SEAT RECLINER MTR
PASS SEAT CTRL SW
BLK WHT
BLK WHT
BLK WHT
BLK WHT
PASS SEAT RECLINER SW
PASS SEAT RECLINER MTR
BLK WHT
BLK WHT
PASS PWR LUMBAR SW
BLK WHT
BLK
PASS PWR LUMBAR COMP MTR
BLK WHT
BLK WHT
DRVR PWR LUMBAR SW
BLK WHT
BLK
DRVR PWR LUMBAR COMP MTR
BLK WHT
BLK YEL
ORG
YEL
ORG
N C
PASS HEATED SEAT SW
YEL
BLK
ORG
YEL
YEL
PASS HEATED SEAT RLY
YEL
BLK
HEATED SEAT ON IND
YEL
BLK
PASS HEATED SEAT BACK PAD
BN
PASS HEATED SEAT CUSHION
FUSE #5
PPL ORG
BLK
BLK WHT
BLK YEL
HEATED SEAT RLY
ORG
ORG
BLK YEL
YEL
N C
DRVR HEATED SEAT SW
BLK
DRVR HEATED SEAT BACK PAD
BRN
YEL
DRVR HEATED SEAT CUSHION
BLK
YEL
YEL
YEL
ORG
DRVR HEATED SEAT RLY
YEL
BLK
HEATED SEAT ON IND
TRUNK RELEASE SW
CLOCK
WHT PPL
WHT PPL
RADIO ILLUM RLY OR CLSTR ILLUM RLY
PPL YEL
PPL YEL
PPL YEL
KEYLESS ENTRY MOD
TRUNK RELEASE SOL
BLK
FILLER DOOR RELEASE SW
HORN RLY
YEL LT BLU
WHT PNK
FILLER DOOR RELEASE SOL
BLK
DOWN
UP
DOWN
UP
BLK
PWR ANTENNA MOTOR
YEL BLK
FUSE #11
PWR ANTENNA SW
REAR WINDOW DEFOG GRID
GRY YEL
BLK FUS LINK
YEL
FUSE #17
LT BLU PNK
BLK
REAR WDO DEFOG SW W/O EATC)
LT BLU PNK
FUSE #17
RADIO ILLUM RLY OR CLSTR ILLUM RLY
LT BLU RED
LT BLU RED
GRY YEL
BLK FUS LINK
LT BLU PNK
(2.3L)
(3.8L & 5.0L)
LT BLU PNK
GRY LT BLU
GRY LT BLU
BLK
YEL
GRY YEL
LT BLU PNK
LT BLU PK
BLK
GRY LT BLU
REAR WINDOW DEFOG SW
REAR WINDOW DEFOG GRID
REAR DEFOG CTRL (W/EATC)

REAR COMPARTMENT & ACCESSORIES

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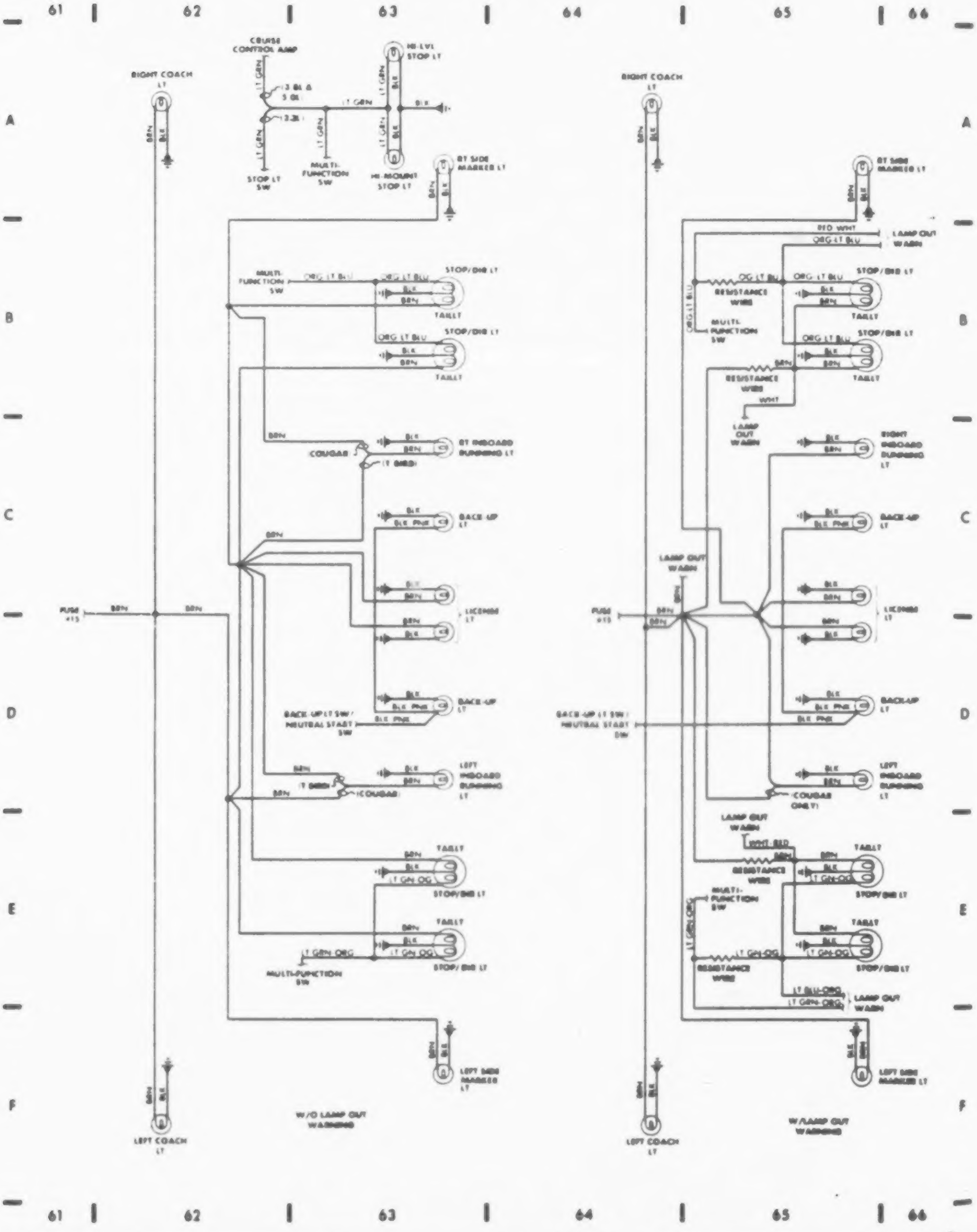

61
62
63
64
65
66
A
B
C
D
E
F
CRUISE CONTROL AMP
HI-LVL STOP LT
RIGHT COACH LT
(3.8L & 5.0L)
(2.3L)
LT GRN
BLK
BRN
STOP LT SW
MULTI-FUNCTION SW
HI-MOUNT STOP LT
RT SIDE MARKER LT
ORG LT BLU
STOP/DIR LT
TAILLT
COUGAR
(T BIRD)
RT INBOARD RUNNING LT
BACK-UP LT
BLK PNK
FUSE #15
LICENSE LT
BACK-UP LT SW/ NEUTRAL START SW
LEFT INBOARD RUNNING LT
(COUGAR)
LT GN OG
LT GRN ORG
LEFT SIDE MARKER LT
W/O LAMP OUT WARNING
LEFT COACH LT
RED WHT
LAMP OUT WARN
RESISTANCE WIRE
WHT
RIGHT INBOARD RUNNING LT
(COUGAR ONLY)
WHT RED
LT BLU-ORG
LT GRN-ORG
W/LAMP OUT WARNING

ACTIVITY SHEET 1

MISCELLANEOUS ELECTRICAL COMPONENTS IX

REPORT ON OTHER ELECTRICAL COMPONENTS

COMPARE THEN TO NOW

Find a service manual for an automobile made in 1970 or before. Compare the clock, radio, cruise control, and security system to those in a modern car of the same or a similar make. Note those systems that are not available in the older car. Compare the components, circuit operation, and service of the two cars. Report your findings to the class or make a poster.

COMPARE NOW TO TOMORROW

Visit a customizer or survey automotive magazines to discover what changes in the clock, radio, cruise control, and security systems we can expect to see in the future. Compare the components, circuit operation, and service of today's and tomorrow's cars. Also note any systems we do not have today, but will have soon. Report your findings to the class or make a poster.

MAKE A MODEL SYSTEM

Singly or as a team, design a new or improved electrical system. The system may be a safety or comfort feature. Draw a diagram of the system and write a description of how it would operate or construct a model of the system. Present your idea to the class.

ASSIGNMENT SHEET 1

MISCELLANEOUS ELECTRICAL COMPONENTS IX

NAME ______________________________ SCORE ________

OBJECTIVE 8 **Diagnose entertainment circuit problems.**

INTRODUCTION

Everyone knows how to operate a radio: You turn it on and it plays. Unfortunately, this isn't really all there is to it. Today's entertainment systems are complicated, sophisticated, electronic devices designed to produce quality sound in the worst acoustical setting possible—the car. The setting, the complicated instrumentation, and the lack of owner knowledge combine to make diagnosing entertainment system problems a challenge. Consider this true situation: A customer spends several hundred dollars on a new stereo system and carefully tunes it before leaving home. Every time he turns a corner, though, the back speakers on one side lose all their volume. He takes the car to the service representative who tests all components and the circuitry thoroughly and finds no fault. Only then does someone notice the box of tissues sitting in the back window. Every time the driver turned a corner, the box slid across the shelf, stopping on top of a speaker.

Most diagnoses do not require such investigative skills. What is required is a thorough understanding of the circuit, a logical approach to locating the source of the problem, and a service manual. Diagnosis begins with talking to the customer and observing the problem. Be sure the customer understands how to use the system and that all settings are correct. If a problem does exist in the system, begin by determining what is not causing it. By logically and systematically narrowing down the possible sources of the trouble, an accurate diagnosis is most easily made.

DIRECTIONS

Use the flowcharts in Supplements 1-12 to answer the questions below.

1. What is the first step in diagnosing an entertainment system problem? ______________________________

2. If a sound system tuned to a strong station while the ignition is in the ACCESSORY position does not produce any sound but does light up, what should be checked first?

____

3. If all speakers seem to be malfunctioning, should you test each speaker? ________.

4. A customer complains of static and noise when she is driving to work each morning. She mentions that she works in the downtown district of a large city. What should you do and why?

____

____

____

5. If a customer complains of static and noise and you hear the noise when the ignition is turned to ON without the engine running, but not when it is turned to ACCESSORY, should you check the radio? __________.

6. Can noise heard when the ignition is in ACCESSORY and all accessories are turned off be caused by a loose antenna?

__________.

7. Where should a weak radio reception problem be checked?

____________________.

8. If a radio only picks up strong local stations, what should be plugged into the radio? ____________________

____

9. If a system has only intermittent reception even after the radio is replaced, what should be tested? ______________

____

10. Why is the operation of a cigarette lighter important in diagnosing radio display problems?

11. What is the most likely problem if only AM is received?

12 When diagnosing cassette player problems, what is replaced for testing?

ASSIGNMENT SHEET 2

MISCELLANEOUS ELECTRICAL COMPONENTS

IX

NAME ______________________ SCORE ________

OBJECTIVE 9

Diagnose clock circuit problems.

INTRODUCTION

Clock circuits are relatively small. They are connected in circuit with other loads that always receive current, usually the cigarette lighter or courtesy lamps. To diagnose clock circuit problems, check the performance of other loads connected to the circuit and, by a logical series of eliminations, locate the source of the problem. If the clock is a stand-alone unit, it is easily removed and replaced. If it is part of the radio readout, the radio should be removed and sent to a repair station. Incorrect display is a common clock circuit problem. If the clock is part of the radio, the radio readout will also be incorrect. This problem is usually caused by removing the battery. The clock must receive constant voltage. Removing the battery stops the flow of current and the clock loses its memory. To solve this problem, you should follow manufacturer's directions for resetting the clock.

DIRECTIONS

Use the information above to determine what effect the following faults might have on the clock.

1. Loose circuit connection ______________________

   ____

2. Blown courtesy fuse ______________________

   ____

3. Loose antenna connections (if the clock is part of the radio)

   ____

4. Worn or damaged battery ______________________

   ____

5. Faulty ignition switch ______________________

   ____

6. Ground in the wiring to the cigarette lighter ________________

____

ASSIGNMENT SHEET 3

MISCELLANEOUS ELECTRICAL COMPONENTS IX

NAME ______________________ SCORE ______

OBJECTIVE 10

Diagnose cruise control problems.

INTRODUCTION

Cruise control system diagnosis varies widely among makes and models. For instance, Cadillac Deville and Fleetwood service procedures begin with checking for trouble codes stored in the on-board computer; General Motors suggests checking the servo and throttle linkages and hose routings; and Ford suggests checking connections and brake lights. While testing and servicing procedures in the manufacturer's service manual should always be followed, the troubleshooting chart found in Supplement 13 is a basic list of symptoms and causes. This chart assumes the sensor and servo are connected to the speedometer.

DIRECTIONS

Using the information in Supplements 13 and 14, list the problems that can be caused by the items listed below.

1. Defective servo ______________________

2. Faulty electrical circuit

3. Blown fuse

4. Speed control cable kinked or damaged

5. Speedometer cable kinked or damaged

6. Improper cruise control throttle cable adjustment

7. Vacuum leak

ASSIGNMENT SHEET 4

MISCELLANEOUS ELECTRICAL COMPONENTS IX

NAME ______________________________ SCORE ______

OBJECTIVE 11

Diagnose security system problems.

INTRODUCTION

Like cruise control systems, security systems vary among makes and models. A variety of after-market security systems are also available. Once again, using the proper service manual is a must.

Security system problem diagnosis is a logical, cause/effect progression of determining where the problem lies. You should check system literature for the operation of the system and information about the zones protected by the system. You should also determine what other systems are connected in circuit and observe their performance. From here it is a simple matter of testing components and circuitry for indicated faults, similar to tracing lighting system failures. Two important things to remember when servicing security systems are to check grounds for good, clean connections and to only replace fuses with new fuses of the proper size.

DIRECTIONS

Use the information in Supplement 15 to answer the questions below.

1. If the car will not start, the voltage at terminal 1C of the relay should measure ______.

2. The alarm deactivation verification takes place with the window down and alarm system armed. If a car door is unlocked and opened from the inside, then a key is inserted and turned to unlock, the alarm should ______________________________.

3. If the horns turn off and on, but the tail and parking lights do not, what two items should be serviced?

____

____

4. If the system does not activate when the trunk is opened and lock cylinder removed, where should voltage be measured?

   ____

5. How long should the warning light remain lit after closing vehicle doors and arming system? ____________________

ASSIGNMENT ANSWERS

MISCELLANEOUS ELECTRICAL COMPONENTS IX

ASSIGNMENT SHEET 1

1. Verify complaint
2. Connections at back of radio
3. No
4. No service because the large buildings are causing interference (and check service bulletins)
5. No
6. Yes
7. Outdoors
8. A test antenna
9. The speakers
10. Display memory and cigar lighter are on the same circuit.
11. Bad antenna connections
12. The cassette tape because it may be worn or defective

ASSIGNMENT SHEET 2

1. Loss of memory and improper or no display
2. Loss of memory and improper or no display
3. No effect
4. Loss of memory and improper or no display
5. No effect
6. Loss of memory and improper or no display

ASSIGNMENT SHEET 3

1. Defective servo
    - No cruise control when button pressed
    - No automatic release with brake pedal depressed
    - Cruise control engages without actuating speed set button
    - Speedometer noise, excessive needle flutter or erratic servo lock-in performance
    - Speed setting after lock-in is too high or too low
    - Resume speed possible below 20 m.p.h.
    - Cruise control engages when engine started or does not disengage with pedal is depressed

2. Faulty electrical circuit

    - No cruise control when button pressed
    - No resume when slide switch moved
    - No automatic release with brake pedal depressed
    - Cruise control engages without actuating speed set button
    - Unit disengages on rough road

- Resume speed possible below 20 m.p.h.
- Cruise control engages when engine started or does not disengage with pedal depressed

3. Blown fuse

    - No cruise control when button pressed

4. Speed control cable kinked or damaged

    - No automatic release with brake pedal depressed
    - Engine does not return to normal idle

5. Speedometer cable kinked or damaged

    - Speedometer noise, excessive needle flutter or erratic servo lock-in performance

6. Improper cruise control throttle cable adjustment

    - Speed setting after lock-in is too high or too low

7. Vacuum leak

    - No cruise control when button pressed
    - Speed setting after lock-in is too high or too low

ASSIGNMENT SHEET 4

1. 2V
2. Activate, then turn off
3. Alarm relay contact
   Circuit #13
4. Terminal C
5. 32 seconds

JOB SHEET 1 *MISCELLANEOUS ELECTRICAL COMPONENTS* *IX*

OBJECTIVE 12a **Inspect and replace speakers.**

TOOLS AND EQUIPMENT

- Ohmmeter
- Voltmeter
- Service manual
- Known good test speaker
- Safety glasses
- Seat covers
- Floor mat

PROCEDURE

1. Discuss the problem with the owner. Review system operation and check settings.

2. Check speakers for debris, blockage, or damage. Pebbles or other items may be caught in the speaker, the driver may have blocked the speakers, or the speaker fabric may be torn.

3. Perform the tests below.

SPEAKER TEST 1

1. Disconnect speaker wires.

2. Connect an analog ohmmeter set at RX 1 scale across the speaker terminals.

    a. If the speaker pops, the speaker is receiving current. This does not insure quality performance and further tests should be conducted.

    b. If the speaker does not pop, it is defective and should be removed and replaced.

SPEAKER TEST 2

1. Put the ignition in ON and the radio on HIGH.

2. Connect a voltmeter across speaker outputs.

    a. If the voltage varies around 1V, check the wiring between the radio and the speaker for fault.

    b. If voltage is not varying around 1V, remove the radio and service it.

REPLACEMENT SPEAKER TEST

1. Remove speaker.

2. Insert a known good speaker.

3. Operate the sound system.

    a. If the system works with the new speaker, the old speaker is defective.

    b. If the system still fails, test wiring to speakers for continuity and repair faults. If continuity is good, replace radio.

4. Have your instructor check your work.

5. Put away tools and materials and clean the work area.

JOB SHEET 2

MISCELLANEOUS ELECTRICAL COMPONENTS IX

OBJECTIVE 12b

Inspect and replace power antenna.

TOOLS AND EQUIPMENT

- Known good test antenna
- Coaxial
- Service manual
- Ohmmeter
- Safety glasses
- Seat covers
- Floor mats

PROCEDURE

1. Unplug the antenna and plug in a known good antenna. Ground the antenna without touching the antenna mast. Adjust dial to both ends and test AM and FM reception. If reception with the replacement antenna is good, the power antenna is faulty. If reception with the replacement antenna is bad, remove the radio and service. Determine the problem as described below.

2. Locate service manual procedures and follow service instructions.

IF THE ANTENNA DOESN'T RAISE OR LOWER

1. Check antenna for bends or other damage.

2. Check fuses. If fuses are bad, replace them. If they blow again, trace the wire for a ground and repair it. If no ground is found, test antenna motor.

3. Check connections and circuit continuity at the antenna relay.

BASIC ANTENNA TEST

1. Disconnect antenna from radio (usually a plug on the side or rear of the radio).

2. Connect a known good antenna.

3. Ground the antenna.

   NOTE: Be sure you do not touch the mast while the antenna is grounded or test results will not be accurate.

4. If performance improves, replace the antenna.

5. If there is no change in performance, remove the radio for servicing.

IF RECEPTION IS WEAK OR FADING

1. Remove and disassemble antenna according to manufacturer's service manual procedures.

2. Clean drive housing.

3. Reassemble and test.

4. If reception is still bad, replace drive housing.

IF THERE IS EXCESS IGNITION NOISE OR ERRATIC AUDIO RECEPTION

1. Check antenna ground.

IF THERE IS NO AM AND POOR FM RECEPTION

1. Test the lead-in cable resistance with an ohmmeter. As you measure the resistance, gently wiggle the lead-in tip and cable. Test results should meet specs listed in the service manual.

FINAL STEPS FOR ALL TESTS

1. Have your instructor check your work.

2. Put away tools and materials and clean the work area.

JOB SHEET 3

MISCELLANEOUS ELECTRICAL COMPONENTS IX

OBJECTIVE 12c

Inspect and repair cruise control non-electrical components.

TOOLS AND EQUIPMENT

- Service manual
- Vacuum pump
- Safety glasses
- Fender covers
- Floor mat
- Seat covers

PROCEDURE

1. Perform basic service or troubleshooting procedures according to service manual. These should include visually checking linkages and hose and may include self-diagnostic tests.

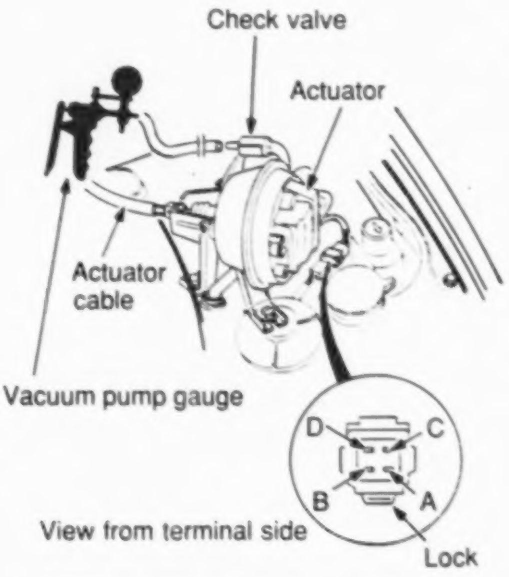
2. Perform the following non-electrical part servicing steps as indicated.

ACTUATOR TEST

1. Disconnect the actuator cable from the actuator rod and electrical connectors.

2. Refer to the service manual.

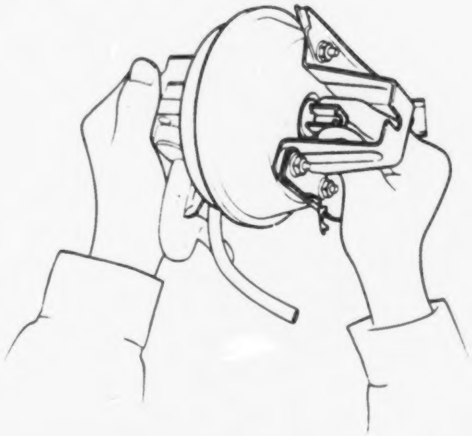
3. Connect the check valve to a vacuum pump and apply vacuum to the actuator.


Check valve
Actuator
Actuator cable
Vacuum pump gauge
D
C
B
A
View from terminal side
Lock

Used with permission of American Honda Company.

4. The actuator rod should pull completely in. If not, check the vacuum line for leaks and test the solenoid.

5. While applying vacuum, try pulling out the actuator rod by hand. If you can, it is defective and should be replaced.



Used with permission of American Honda Company.

6. Repeat previous test. This time the actuator rod should be pushed out rather than being pulled into the actuator.

ACTUATOR CABLE ADJUSTMENT

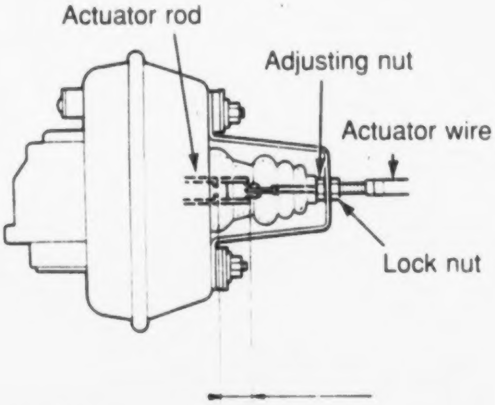
1. Visually check the actuator cable for binding or sticking.

2. Start the engine.

3. Measure the amount of actuator rod movement before the cable pulls the accelerator lever. Compare this to service manual specs.

4. If the measurement is not within limits, loosen the locknut and turn the adjusting nut.

5. Tighten the locknut and remeasure.


Actuator rod
Adjusting nut
Actuator wire
Lock nut

Locknut free play: 11 ± 1.5mm
(0.43 ± 0.06 in)

Used with permission of American Honda Company.

6. Have your instructor check your work.

7. Put away tools and materials and clean the work area.

JOB SHEET 4

MISCELLANEOUS ELECTRICAL COMPONENTS

IX

OBJECTIVE 12d

Inspect and repair cruise control electrical components.

TOOLS AND EQUIPMENT

- Service manual
- Ohmmeter
- Test lamp
- Jumper wires
- Safety glasses
- Floor mats
- Fender covers
- Seat covers

PROCEDURE

1. Perform troubleshooting procedures and self-diagnostic tests, as instructed in the service manual.

2. In the service manual, locate instructions for and complete the following tests:

    a. Servo test

    b. Switch tests

    c. Sensor tests

3. Adjust the system as indicated, following service manual procedures.

4. Operate system to test performance.

5. Have your instructor check your work.

6. Put away tools and materials and clean the work area.

JOB SHEET 1

Inspect and replace speakers.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Discussed problem with owner. Reviewed system operation and checked settings.	_____	_____
2. Checked speakers for debris, blockage, or damage.	_____	_____
3. Performed:		
a. SPEAKER TEST 1		
1) Disconnected speaker wires.	_____	_____
2) Connected an analog ohmmeter set at RX 1 scale across the speaker terminals.	_____	_____
3) Made proper diagnosis.	_____	_____
b. SPEAKER TEST 2		
1) Put the ignition in ON and the radio on HIGH.	_____	_____
2) Connected a voltmeter across speaker outputs.		
a. If the voltage varied around 1V, checked wiring between radio and speaker for fault.	_____	_____

	YES	NO
b. If voltage did not vary around 1V, removed the radio for servicing.	____	____
c. REPLACEMENT SPEAKER TEST		
1) Removed speaker.	____	____
2) Inserted a known good speaker.	____	____
3) Operated the sound system.	____	____
4) Made a correct diagnosis.	____	____
4. Used proper tools correctly.	____	____
5. Performed steps in a timely manner.	____	____
6. Practiced safety rules throughout procedure.	____	____
7. Provided satisfactory responses to questions asked.	____	____
8. Put away tools and materials and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Discussed problem with owner, reviewed system operation and checked settings	4	3	2	1
Performed Speaker Test 1 carefully and made correct diagnosis	4	3	2	1
Performed Speaker Test 2 carefully and made correct diagnosis	4	3	2	1
Performed Replacement Speaker Test carefully and made correct diagnosis	4	3	2	1
Repaired or replaced speaker correctly	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" on the following page.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 2

MISCELLANEOUS ELECTRICAL COMPONENTS IX

JOB SHEET 2

Inspect and replace power antenna.

STUDENT'S NAME ____________ DATE ____________

EVALUATOR'S NAME ____________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Unplugged antenna and plugged in a known good antenna.	_____	_____
2. Grounded the antenna without touching antenna mast.	_____	_____
3. Adjusted dial to both ends and tested AM and FM reception.	_____	_____
4. Determined type of problem and located service manual information.	_____	_____
IF THE ANTENNA DIDN'T RAISE OR LOWER		
1. Checked fuses.	_____	_____
2. Removed the relay and replaced fuses.	_____	_____
3. If they blew again, traced the wire for a short and repaired it.	_____	_____
4. If no short was found, tested antenna motor.	_____	_____

	YES	NO
IF RECEPTION WAS WEAK OR FADING		
1. Removed and disassembled antenna according to manufacturer's service manual procedures.	____	____
2. Cleaned drive housing.	____	____
3. Reassembled and tested.	____	____
4. If reception was still bad, replaced drive housing.	____	____
IF THERE WAS EXCESS IGNITION NOISE OR ERRATIC AUDIO RECEPTION		
1. Checked antenna ground.	____	____
IF THERE WAS NO AM AND POOR FM RECEPTION		
1. Tested the lead in cable resistance with an ohmmeter.	____	____
2. Compared results to specs listed in the service manual.	____	____
FOR ALL TESTS		
1. Used proper tools correctly.	____	____
2. Performed steps in a timely manner.	____	____
3. Practiced safety rules throughout procedure.	____	____
4. Provided satisfactory responses to questions asked.	____	____
5. Put away tools and materials and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Substituted a known good antenna	4	3	2	1
Tested AM and FM reception at both ends of the dial	4	3	2	1
IF THE ANTENNA DIDN'T RAISE OR LOWER				
Checked fuses, removed relay, and replaced fuses	4	3	2	1
Tested wiring, antenna motor, connections or continuity, as indicated	4	3	2	1
IF RECEPTION WAS WEAK OR FADING				
Removed and disassembled antenna according to service manual procedures	4	3	2	1
Cleaned drive housing, reassembled and retested	4	3	2	1
IF THERE WAS EXCESSIVE NOISE OR ERRATIC AUDIO RECEPTION				
Carefully checked antenna ground	4	3	2	1

IF THERE WAS NO AM AND POOR FM RECEPTION				
	4	3	2	1
Tested the lead-in cable and compared results to service manual specs				

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 —	Skilled — Can perform job with no additional training.
3 —	Moderately skilled — Has performed job during training program; limited additional training may be required.
2 —	Limited skill — Has performed job during training program; additional training is required to develop skill.
1 —	Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 3

MISCELLANEOUS ELECTRICAL COMPONENTS *IX*

JOB SHEET 3

Inspect and repair cruise control non-electrical components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student YES NO

1. Performed basic service or troubleshooting procedures according to service manual. _____ _____
2. Performed:
   a. ACTUATOR TEST
      1) Disconnected the actuator cable from the actuator rod and electrical connectors. _____ _____
      2) Connected the check valve to a vacuum pump and applied vacuum to the actuator. _____ _____
      3) Checked the vacuum line for leaks and tested the solenoid. _____ _____
      4) While applying vacuum and voltage, tried pulling out the actuator rod by hand. _____ _____
      5) Repeated previous test, disconnecting battery from the terminal as instructed in service manual. This time the actuator rod should have pushed out rather than pulling into the actuator. _____ _____

	YES	NO
b. ACTUATOR CABLE ADJUSTMENT		
1) Visually checked the actuator cable for binding or sticking.	____	____
2) Measured the amount of actuator rod movement before the cable pulled the accelerator lever.	____	____
3) Compared this to service manual specs.	____	____
4) If the measurement was not within limits, loosened the locknut and turned the adjusting nut; tightened the locknut and remeasured.	____	____
3. Used proper tools correctly.	____	____
4. Performed steps in a timely manner.	____	____
5. Practiced safety rules throughout procedure.	____	____
6. Provided satisfactory responses to questions asked.	____	____
7. Put away tools and materials and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
	4	3	2	1
Performed basic service or troubleshooting procedures according to service manual				
	4	3	2	1
Performed the actuator test as instructed in service manual				
	4	3	2	1
Adjusted actuator cable as instructed in service manual				

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TEST 4

MISCELLANEOUS ELECTRICAL COMPONENTS

IX

JOB SHEET 4

Inspect and repair cruise control electrical components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student	YES	NO
1. Performed troubleshooting procedures and self-diagnostic tests as described in the service manual.	_____	_____
2. In the service manual, located instructions for and completed the following tests:		
a. Servo test	_____	_____
b. Switch tests	_____	_____
c. Sensor tests	_____	_____
3. Adjusted the system as indicted, following service manual procedures.	_____	_____
4. Operated system to test performance.	_____	_____
5. Used proper tools correctly.	_____	_____
6. Performed steps in a timely manner.	_____	_____
7. Practiced safety rules throughout procedure.	_____	_____

	YES	NO
8. Provided satisfactory responses to questions asked.	____	____
9. Put away tools and materials and cleaned work area.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See performance evaluation key.) A student who is unable to demonstrate mastery should review the materials and repeat the procedure for evaluation.

Criteria				
Performed troubleshooting procedures and self-diagnostic tests correctly	4	3	2	1
Performed Servo test	4	3	2	1
Performed Switch tests	4	3	2	1
Performed Sensor tests	4	3	2	1
Adjusted the system as indicated	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria. Circle the rating on the "Performance Evaluation Key" below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

MISCELLANEOUS ELECTRICAL COMPONENTS IX

NAME ______________________ SCORE ________

OBJECTIVE 1

Define terms associated with servicing miscellaneous electrical components.

- After-market — ______________________
  ____
- Servo — ______________________
  ____

OBJECTIVE 2

List components of entertainment circuits.

____

____

____

____

____

____

____

OBJECTIVE 3

Select from a list components of clock circuits. Write an "X" in the blanks before components in a clock circuit.

_____1. Clock

_____2. Clock motor

_____3. Fuse block

_____4. Clock memory (if digital)

_____5. Clock logic unit

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______ 6. Wiring and connectors

______ 7. Clock solenoid

OBJECTIVE 4 **Complete statements about cruise control circuits.**

1. The Vehicle Speed Sensor (VSS) receives ______________ (usually magnetic pulses) indicating the speed of the vehicle and sends this information to a control or servo unit.

2. The control or servo unit receives information from the VSS and compares it to input from the ______________ ______________ ______________ indicating the speed desired by the driver.

3. The control or servo unit sends current to solenoids that either ______________ or ______________ vacuum pressure on a ______________ connected to throttle linkages.

4. The ______________, moved by the diaphragm, move the ______________ and speed is increased or decreased.

OBJECTIVE 5 **Select from a list true statements about cruise control designs.** Write an "X" in the blanks before true statements.

______ 1. The VSS is located within the on-board computer.

______ 2. Designs vary among makes and models.

______ 3. One major design difference is the location of the VSS.

______4. The blade attached to the speedometer cable taps a shock sensor which counts the vibrations and calculates speed.

______5. The VSS may be located on the transaxle.

______6. Cruise control systems are all basically the same.

______7. A magnet rotates within the transaxle and the VSS picks up the magnetic pulses as it passes. These voltage pulses are used to calculate the speed of the transaxle shaft rotation and then the speed of the car.

______8. A VSS on the transaxle senses the velocity of wind passing under the car and calculates speed.

______9. The vehicle speed can be determined by attaching a reflective blade to the speedometer cable.

______10. Light from a LED aimed at the blade is sensed by a optic head and the light pulses are used to calculate vehicle speed.

OBJECTIVE 6 **List components of security systems.**

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OBJECTIVE 7 **Discuss security system designs.**

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____

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NOTICE	The following assignment sheets and job sheets are not part of the written test. If these activities have not been completed, check with your instructor.	
OBJECTIVE 8	**Diagnose entertainment circuit problems.**	SCORE ______
OBJECTIVE 9	**Diagnose clock circuit problems.**	SCORE ______
OBJECTIVE 10	**Diagnose cruise control problems.**	SCORE ______
OBJECTIVE 11	**Diagnose security system problems.**	SCORE ______
OBJECTIVE 12a	**Inspect and replace speakers.**	RATING ______
OBJECTIVE 12b	**Inspect and replace power antenna.**	RATING ______
OBJECTIVE 12c	**Inspect and repair cruise control non-electrical components.**	RATING ______
OBJECTIVE 12d	**Inspect and repair cruise control electrical components.**	RATING ______

WRITTEN TEST ANSWERS

MISCELLANEOUS ELECTRICAL COMPONENTS IX

OBJECTIVE 1

1. After-market — Components sold separately from the automobile and added to it
2. Servo — A system in which input and output are compared to determine the desired control

OBJECTIVE 2

1. Entertainment system control head
2. Amplifier
3. Speaker
4. Antenna
5. Wiring and connectors
6. Fuse block
7. Ignition switch

OBJECTIVE 3

1, 3, 4, 6

OBJECTIVE 4

1. input
2. cruise control switch
3. increase
   vent
   diaphragm
4. linkages
   throttle

OBJECTIVE 5

2, 3, 5, 7, 9, 10

OBJECTIVE 6

1. Controller
2. Switches
3. Alarm relay
4. Starter interrupt relay
5. Horn
6. Exterior lights
7. Disarm relay

OBJECTIVE 7

Answer should include:

- Security system designs vary among makes and models.
- Security systems become armed when the car is parked, the key is removed from the ignition, and the doors are locked.
- Sensors and switches in strategic locations throughout the car activate the system if tripped.
- Typically, attempted theft causes the circuit to become grounded and current is sent to an alarm system that honks the horn and flashes lights.
- Many security systems now include a starter disable. These units prevent the starter working if the system is tripped or if certain starting procedures are not used.
- Two types are active and passive.

OBJECTIVE 8

Refer to answers to Assignment Sheet 1.

OBJECTIVE 9

Refer to answers to Assignment Sheet 2.

OBJECTIVE 10

Refer to answers to Assignment Sheet 3.

OBJECTIVE 11

Refer to answers to Assignment Sheet 4.

OBJECTIVE 12

Refer to Practical Tests for Job Sheets 1-4.

	ORAL COMMUNICATIONS SKILLS																							INTERPERSONA																	
	Oral Presentation									Listening				Interactive Communication										General Relating																	
UNITS OF INSTRUCTION STATE/LOCAL CODES*	Make informative presentations	Make persuasive presentations	Present personal opinion/viewpoint	Use good speaking techniques	Select/use words effectively	Use effective body language	Present appropriate appearance	Integrate audio and/or visual materials in oral presentations	Adapt presentation to specific audience	Apply active listening skills	Distinguish fact, opinion, and interference	Draw conclusions/make generalizations	Analyze/identify point of view	Give/follow oral directions	Apply questioning techniques	Conduct/receive interviews	Analyze/apply nonverbal communication	Work effectively in a group	Communicate with clients/ customers/patients	Communicate with co-workers	Communicate with supervisors	Communicate with professional colleagues/associates	Apply telephone etiquette	Investigate/apply communication process models	Analyze/apply nonverbal communication	Investigate/apply cross-cultural communication	Interact with co-workers	Interact with supervisors	Interact with clients/customers/patients	Interact with professional colleagues/associates	Interact with family/friends	Participate in group activities	Participate in industrial relations/functions	Identify personal values/attitudes	Apply information to life experiences	Identify values/attitudes	Identify needs/drives	Select/apply appropriate behavior	Investigate/identify personal styles	Investigate/identify group/
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Electronic System Repair Req.																					●								●											
Starting System																																									
Charging System																																									
Lighting System																																									
Horn and Wiper/Washer System	●			●	●	●	●	●														●																			
Motorized Accessories	●			●	●	●	●																							●											
Driver Information Systems				●	●	●	●	●														●								●											
Misc. Electrical Components	●			●	●	●	●																						●	●											

*Use this line for entering your state and local codes for graduation requirements or learner outcomes

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NAL OR RELATING SKILLS

Teamwork Cooperation

Investigate/identify group/corporate climate	Give/receive feedback	Identify hidden purposes	Investigate/apply group dynamics	Control undesirable/inappropriate behavior	Resolve conflicts	Clarify goals/objectives	Devise "win-win" situations	Build consensus	Generate ideas	Present point of view

Leadership Influence

Analyze/apply leadership styles	Analyze/apply management styles	Obtain confidence of others	Develop esteem in self/others	Persuade others	Analyze/apply motivation techniques	Provide positive coaching

CREATIVE THINKING/ PROBLEM SOLVING SKILLS

Cognitive Activities

Collect/record information	Identify critical elements/issues	Define a problem	Identify underlying causes	Apply a problem-solving model	Analyze/synthesize information	Identify/analyze underlying assumptions	Draw conclusions	Predict results/outcomes	Identify/evaluate consequences	Identify/develop alternatives	Evaluate alternatives	Select an alternative	Devise a solution	Create a finished product	Apply intuitive/creative thinking processes	Transfer knowledge/training to new situations	Apply new technology	Develop an action plan	Evaluate results/outcomes
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Job Search Selection

Analyze personal occupational aptitudes/preferences	Investigate employment prospects of a career field/occupation	Investigate training requirements for a career field/occupation	Investigate benefits of a career field occupation	Compare/evaluate career options	Develop personal career path	Locate appropriate jobs	Analyze duties/requirements/benefits of specific job

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MPLOYABILITY SKILLS

SOCIAL STUDIES SKILLS

	Job Acquisition Development														Information Analysis						Social Studies Application										Functional Social Studies														
of specific job	Master specific job task/procedure	Fill in job-related applications	Write letter of application	Write personal resume	Interview for a job	Apply business etiquette	Practice good work habits/attitudes	Develop good personal presentation	Develop self-confidence/esteem	Develop effective leadership	Deal effectively with supervisors	Deal effectively with co-workers	Deal effectively with professional colleagues/associates	Deal effectively with customers/clients	Collect/record data	Interpret graphical information	Construct graphical information	Interpret maps/globes	Interpret statistical information	Analyze/interpret demographic information	Investigate/apply U.S. history	Investigate/apply world history	Investigate/apply U.S. geography	Investigate/apply world geography	Investigate/apply principles of government/politics	Investigate/apply principles of economics	Investigate/apply principles of ethics	Investigate/apply principles of psychology	Investigate/apply principles of sociology	Investigate/apply cross-cultural studies	Practice responsible personal economics	Prepare a personal budget	Use credit responsibly	Practice good work ethics	Participate in industrial relations	Interact with people of different races/cultures	Investigate/participate in government	Investigate/apply American legal practices	Select/use sources of information on current events	Analyze current events	Analyze consumer issues	Analyze social issues	Analyze conservation/ecology issues	Analyze social impact of science/technology	Analyze economic impact of science/technology
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AUTOMOTIVE ELECTRICAL SYSTEMS SPECIALIST

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READING SKILLS

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UNITS OF INSTRUCTION STATE LOCAL CODES*	Reading Comprehension									Research and Reference								Functional Reading						Language		Composition								Researc		
	Gain factual information	Distinguish fact, opinion and inference	Recognize stereotyping and bias	Recognize propaganda	Analyze cause and effect	Draw conclusions	Make generalizations	React to written material	Apply word analysis techniques	Select useful resources	Locate resources	Find materials in library	Use standard references	Use in-book reference tools	Use audiovisual media	Use computer data base	Use magazines and newspapers	Interpret forms and records	Follow written instructions	Interpret graphics and symbols	Use content area vocabulary	Interpret abbreviations/acronyms	Read aloud	Use standard grammar and correct spelling, punctuation, and capitalization	State ideas clearly	Use complete sentences	Develop preliminary outline	Use topic sentences	Use introductory/closing paragraphs	Compose reports	Compose essays	Proofread and edit	Construct graphics and symbols	Take notes	Use notecards	Create bibliography
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Electronic System Repair Req	●												●	●					●	●				●	●	●		●	●	●		●	●			
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Lighting System	●												●	●					●	●																
Horn and Wiper/Washer System													●						●						●											
Motorized Accessories	●												●	●					●	●				●	●	●		●	●	●		●				
Driver Information Systems	●												●	●					●	●	●				●								●			
Misc. Electrical Components	●										●		●	●					●	●	●			●	●	●										

IMC BASIC SKILLS DOCUMENTATIO

ITING SKILLS

MATH SKILLS

earch			Functional Writing							Operation and Calculation														Math Application											Data Analysis and Display													
Create bibliography	Use footnotes	Outline material	Complete forms and records	Write instructions	**Write letters**	Write job applications	**Write resumes**	Use word processing	**Use computer graphics**	**Round off numbers**	Estimate answers	**Use scientific notation**	Use exponential notations	**Calculate with whole numbers**	Calculate with fractions	**Calculate with decimals**	Convert whole numbers to fractions	**Convert whole numbers to decimals**	Solve numerical expressions	**Solve formulae and equations**	Obtain squares and square roots	**Convert units of measure**	Perform metric calculations	**Solve word problems**	Select/apply mathematical formula	**Select/apply mathematical procedure**	Use English and metric measures	**Solve time/rate/distance problems**	Solve ratio/proportion problems	**Solve percent problems**	Apply techniques of scaling	**Apply algebra principles**	Apply geometry principles	**Apply trigonometry principles**	Interpret charts and tables	Interpret graphs (type)	**Collect /record data**	Apply sampling techniques	**Apply principles of probability**	Construct charts and tables	**Construct graphs**	Calculate statistics	**Interpret statistics**	Interpret blueprints/plans	Make measurements	Perform banking transactions	**Make change**	Solve practical problems
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N MATRIX

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Stillwater, Oklahoma 74074-4364

SCIENCE SKILLS

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Functional Math											General Science									Life Science							Physical Science					Earth Science							
Solve practical problems	Calculate gross earnings	Solve income expense problems	Prepare a budget	Calculate interest	Solve interest problems	Calculate sales tax	Determine income tax	Use calculator for computation	Use computer for computation	Use computer spreadsheets	Apply computing skills	Apply scientific method of inquiry	Conduct experiments	Investigate science ethics	Investigate science history	Investigate/apply economics in technology	Use scientific instruments	Investigate/apply technology	Collect specimens	Identify/classify living organisms	Investigate biological history of the earth	Investigate food chains, webs, pyramids	Investigate/apply principles of human development	Investigate/apply principles of genetics/heredity	Investigate/apply principles of anatomy/physiology	Investigate health issues	Analyze/classify matter	Investigate forms/changes of matter	Investigate forms/changes of energy	Investigate/apply chemical properties	Investigate/apply physical laws	Investigate physical characteristics of the earth	Investigate geological history of the earth	Investigate physical forces acting on the earth	Solve problems of longitude, latitude, and time zones	Investigate conservation of physical resources	Investigate conservation of living resources	Investigate issues of environmental impact	Apply science principles to environmental issues
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